PROCEEDINGS

OF THE

Iowa Academy of Sciences

FOR 1901.

VOLUME IX.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

DES MOINES:
B. MURPHY, STATE PRINTER.
1902.

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LETTER OF TRANSMITTAL.

DES MOINES, Iowa, January 20, 1902.

To His Excellency, Albert B. Cummins, Governor of Iowa:

SIR—In accordance with the provisions of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the sixteenth annual session of the Iowa Academy of Sciences.

Respectfully submitted, your obedient servant,

A. G. LEONARD,
Secretary Iowa Academy of Sciences.

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1901.

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1902.

President.—H. E. SUMMERS.
First Vice-President.—J. L. TILTON.
Second Vice-President.—S. W. BEYER.
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EXECUTIVE COMMITTEE.

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PAST PRESIDENTS.

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OSBORN, HERBERT......................State University, Columbus, Ohio
OWENS, ELIZA...Bozeman, Montana
PATRICK, G. E............Department of Agriculture, Washington, D. C.
READ, C. D......................Weather Bureau, Vicksburg, Mississippi
SIRRINE, F. A..Jamaica, New York
SIRRINE, EMMA..Dysart, Iowa
SPENCER, A. C.............U. S. Geological Survey, Washington, D. C.
TODD, J. E...................State University, Vermillion, South Dakota
TRELEASE, DR. WILLIAM...........................St. Louis, Missouri
UDDEN, J. A...Rock Island, Illinois
WINSLOW ARTHUR....................................Kansas City, Missouri
YOUTZ, L. A..................................New York City, New York

PROCEEDINGS

OF THE

SIXTEENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The sixteenth annual session of the Iowa Academy of Sciences was held in the rooms of the Iowa Geological Survey at the capitol building in Des Moines, December 26 and 27, 1901. In the business session the following matters of general interest were passed upon.

REPORT OF THE SECRETARY.

To the Members of the Iowa Academy of Sciences:

The year 1901 has been one of substantial growth for the Academy. At the fifteenth annual session eleven fellows and seventeen associate members were elected. Of these, nine fellows and fifteen members qualified. Five new names were added to the corresponding membership list; two, Dr. William Trelease, director of the Missouri Botanical Garden, and Prof. J. A. Udden, of Augustana College, Rock Island, Ill., by special election; and three by transfer, Dr. H. F. Bain, now of Idaho Springs, Colo; Prof. John Craig, Cornell University, New York; and L. A. Youtz, a student in Columbia University, New York. On account of the non-payment of dues the names of two fellows and seven members were stricken from the membership list. The revised roster now shows sixty fellows, fifty-eight associate members and forty-five corresponding members, or a total membership of one hundred and sixty-three, the largest in the history of the academy. Messrs. Faurot, Leverett and Miller, fellows of the Academy, have removed from the state and should be transferred to the corresponding membership list. A considerable number of associate members have presented papers for the Academy and are eligible to promotion to the fellowship list. I trust

that the committee on membership may scrutinize these lists very closely and make such recommendations as the best interests of the Academy appear to justify.

The current volume of the proceedings is the largest ever issued and was distributed to those entitled to receive it some months earlier than Volume VII of the preceding year. The amendment to the printing bill passed by the last legislature is not yet sufficiently explicit in its wording. The object of the amendment was to provide for the illustration of the proceedings at state expense. While the intent of the law is clear enough no appropriation was made for the purpose. The bills for illustrations were allowed finally by the state executive council. This defect should be remedied by the new legislature. The Academy has outgrown the statutory limit fixing the maximum size of the volume of the proceedings at 250 pages. Such limit should be stricken out, leaving the matter entirely at the discretion of the Academy officials or a much larger number be substituted. These are matters which ought to receive attention at once and doubtless will be accorded the consideration due them by the legislative committee.

The records of the Academy contain numerous resolutions and recommendations which have long since served their purpose and rightly have been forgotten. The records also contain certain regulations formulated from time to time which are still in force and should be observed or else rescinded. For the information of the newer members of the academy and to quicken the memories of the older ones I take the liberty of presenting the more important regulations.

A. RULES GOVERNING THE ELECTION OF MEMBERS, ETC.

1. It was voted that as a rule the Council should recommend to fellowship only associate members who present themselves with paper, or such other persons as come to us from similar organizations in other states. It was voted that all applications be made out with a statement of qualifications and signed by two fellows of the Academy. Tenth session, January, 1896.

2. It was recommended that associate members on leaving the state be dropped from the Academy roll, unless they signify their wish to retain their associate membership. Twelfth session, 1897.

3. It was ordered that persons owing for reprints be notified if they do not pay this and any delinquent dues promptly their names will be dropped. Fourteenth session, 1899.

B. RULES GOVERNING PUBLICATION, ETC.

1. Members taking part in the discussion of papers and desiring such remarks published may furnish the secretary a written copy of the same. Seventh session, 1892.

2. Authors of papers shall receive 50 separates of their papers at the expense of the Academy, and may receive additional separates at their own expense. Seventh session, 1892.

3. Each member shall receive one copy of the proceedings and have the privilege of buying additional copies at 20 cents each. To persons who are not members the price of the proceedings shall be 50 cents per copy. Seventh session, 1892.

4. That the secretary be authorized to sell pt. 1, Vol. I, at one dollar each and the proceeds to be remitted to Professor Herbert Osborn. Seventh session, 1892.

5. (*a*) That hereafter no papers will be published in the proceedings of the Academy which are not placed in the hands of the secretary, in full or in a written abstract, before the adjournment of the annual meeting. (*b*) That no paper shall be placed upon the printed program of the Academy unless the title, when handed to the secretary, be accompanied by a brief abstract and that these abstracts be printed with the program. Tenth session, January, 1896.

I submit these rules and regulations for your consideration and recommend that those deemed advisable to retain be published in the next volume of the proceedings.

During the past two years the Academy has been fortunate in being able to secure a man, eminent in his chosen line of work, from outside the limits of the state, to deliver an address before the members and their friends, at each session. This year, because of the small size of the Academy bank account, it was deemed advisable to abandon the public address by an imported speaker. Fortunately there will be no hiatus in our program because of the absence of an address delivered by an outsider. Professor Calvin, a charter member of the Academy, has been prevailed upon to give his lecture on "The Ice Age in Iowa," which will conclude our program.

In conclusion I cannot refrain mentioning some of the satisfactions and trials incident to the publication of the proceedings. As you are doubtless aware the state furnishes the paper, and the work of printing and binding is done by the state printer and binder as in the case of the printing of other public documents. The paper furnished for both plates and text is a satisfaction and the press-work is uniformly good. But the dilatory tactics pursued in requiring six months to put a 250 page volume through the press, which at most should not require to exceed six weeks by any first class printing house in the state, is a serious trial. Since our last meeting the office of state printer has changed hands and the new incumbent has adopted a very different schedule of prices for authors' reprints from his predescessor. In settling with the state printer, the secretary was laboring under the impression that the Academy furnished but twenty-five reprints and yet the bill presented, after being several times reduced, was for $64.50. The original bill against the Academy for the twenty-five reprints was some hundred sixty odd dollars. These are matters worthy of the closest attention of the committees on publication and legislation.

Respectfully submitted,

S. W. BEYER,
Secretary.

REPORT OF TREASURER FOR 1901.

RECEIPTS.

Balance from 1900	$ 66.61
Membership dues	74.00
Fellowship dues	21.00
Back dues	20.00
Sale of reports	3.00
Reprints (to be transmitted to state binder)	17.50
Total	$ 202.11

DISBURSEMENTS.

Rent of hall	$ 30.00
Expenses of Professor Trelease	29.59
Binding proceedings fourteenth meeting	25.00
Printing tickets, program and circulars	6.50
Reprints furnished members	35.00
Binding proceedings fifteenth meeting	30.00
Expenses, secretary	2.75
Paid for members to state printer for reprints	17.50
Stamps, secretary, $5.25; treasurer, $2.10	7.35
Expenses, $0.91; clerical work, $1	1.91
Total	$ 185.60
Balance on hand	16.51

At a meeting of the executive council of the Academy the following fellows and members were elected:

FELLOWS.

Louis Begeman, State Normal school, Cedar Falls, Iowa; J. C. Brown, University of Wisconsin, Madison, Wis.; C. H. Eckles, University of Missiouri, Columbia, Mo.; G. E. Finch, Marion, Iowa; J. G. Goodwin, Simpson college, Indianola, Iowa; J. E. Gow, Iowa City, Iowa; H. N. Grettenburg, Marshalltown, Iowa; Dr. G. H. Hill, superintendent Iowa Hospital for the Insane, Independence, Iowa; Herman Mueller, Winterset, Iowa; P. C. Myers, Iowa City, Iowa; Miss Mary Sabin, professor of domestic science, Iowa State College, Ames; Dr. W. E. Sanders, Alta, Iowa; W. N. Stull, Harvard university, Cambridge, Mass.; F. A. Wilder, professor of geology, University of North Dakota, Grand Forks, N. D ; R. B. Wylie, Morningside college, Sioux City, Iowa.

ASSOCIATE MEMBERS.

Walter M. Boehm, State University, Iowa City; William N. Craven, Knoxville; C. E. Gray, Ames; Joseph E. Guthrie, Ames; A. L. Haines, Morningside college, Sioux City; Arthur S. Hamilton, Independence; C. P. Johnson, East Side High School, Des Moines; W. H. Lewis, Winterset; J. H. A. Murphy, Burlington High School, Burlington; E. C. Myers, Ames; G. B. Rigg, Woodbine; J. A Treganza, Britt; W. A. Willard, Grinnell.

CORRESPONDING MEMBERS.

F. W. Faurot, Missouri Botanical Gardens, St. Louis, Mo.; Frank Leverett, Denmark; B. L. Miller, Johns Hopkins University, Baltimore, Md.

The nominating committee reported the following officers for the ensuing year:

President.—H. E. Summers.
First Vice-President.—J. L. Tilton.
Second Vice-President.—S. W. Beyer.
Secretary.—A. G. Leonard.
Treasurer.—B. Shimek.
Elective Members of the Executive Committee.—L. H. Pammel, C. O. Bates, M. F. Arey.

A committee was appointed to draw up resolutions memorializing congress regarding the establishment of forest reserves. On this committee were appointed L. H. Pammel, B. Shimek and M. F. Arey.

RESOLUTIONS OF THE IOWA ACADEMY OF SCIENCES

WITH REFERENCE TO THE ESTABLISHMENT OF FOREST RESERVES BY THE UNITED STATES.

The Iowa Academy of Science approves of President Roosevelt's message on forestry and irrigation, two great internal questions and heartily concurs in the statement that, "The fundamental idea of forestry is the perpetuation of forestry by use. Forest protection is not an end of itself; it is a means to increase and sustain the resources of our country and the industries which depend upon them. The preservation of our forest is an imperative business necessity. We have come to see clearly that whatever destroys the forest except to make way for agriculture threatens our well being." The usefulness of the forest reserve has been demon trated and to have them wisely and justly administered is therefore an imperative necessity. We heartily concur in the recommendations made by Secretary Hitchcock in his annual report that the forest reserves should be under the direction of trained foresters and that forestry, dealing as it does with a source produced by the soil, is an agricultural subject and should ultimately come under the head of the Department of Agriculture if found practicable, because of the trained foresters in the department. This will be to the interests of the reserves and the people who use them. We heartily commend the action of Secretary Hitchcock in creating the Division of Forestry of the Interior Department and appointing men who are specially fitted to look after the management of the reserves, until such time as the forestry work of the government shall be under one management, the United States Department of Agriculture.

In regard to the grazing of sheep in our reserves we are glad to note that a more enlightened policy shall prevail. We commend specially the statement of Mr. Gifford Pinchot, that "the wise adjustment of the grazing question must be a compromise founded on a just consideration of all various interests concerned." The resources of the forests should be wisely used and all matters pertaining to the forest and tributary country should be considered on its merits. We approve most heartily, also, the recommendation of Secretary of Agriculture Wilson in regard to the proposed Appalachian reserve which is urged in order to protect the headwaters of important streams, to maintain an already greatly impaired supply of timber, and to promote a national recreation ground which, with the single exception of the Adirondacks, will be readily accessible to a larger number of people than any other forest region in the United States."

Resolved, That the Iowa Academy of Sciences hereby petitions Congress to take favorable action on the following recommendations:

"1. To set aside for park and forestry purposes the timber tract of the Leach Lake Indian Reservation and other lands at the headwaters of the Mississippi to protect the waters of this great stream which have greatly diminished during the summer months. Also to conserve the immature

white pine and other timbers so useful in the arts and industries. The cutting of mature white pine should be permitted under restrictions laid down by the Interior Department. We favor also the setting apart for similar purposes of such other lands as Congress may control in the states of Wisconsin, Minnesota and other states, to the end that the timber supply of said states may be at least partially saved or restored, and that the forests on such tracts may serve to conserve the moisture and to protect and preserve wild game in said regions. That Congress take favorable action on the recommendations of Secretary Hitchcock with reference to the transfer of forestry work; since the concentration of forestry work is highly desirable to give stability and permanence to the management of the forest reserves.

"2. The purchase of land by the government for a southern Appalachian national park in the Rocky Mountain and Sierra Nevada regions. We favor therefore, the passage of House bill No. 3128 introduced by H. Brownlow.

"3. The withholding from the market by the government of public lands covered with timber and making provisions for the sale of the mature timber thereon under the supervision of a technically trained forester.

"4. The enactment of a law embodying the recommendation of Hon. Binger Herman, commissioner of the general land office, in his last annual report 'that all public lands which are more valuable for forest uses than for other purposes shall be withdrawn from settlement, entry, sale or other disposition and be held for the protection and utilization of the timber thereon, in accordance with the provisions of the forest reservation law.'

"5. The adoption of the recommendation of the said commissioner of the general land office that the president of the United States be vested with the authority to reserve tracts of government land for national park purposes without approval or further action of congress.

"*Resolved*, That the Iowa delegation in Congress is hereby respectfully requested to urge the enactment of laws embodying the recommendations herein contained." Signed,

L. H. PAMMEL, Ames.
B. SHIMEK, Iowa City.
M. F. AREY, Cedar Falls.

The committee on pure food laws, appointed a year ago, was authorized to continue its work and the following resolutions were passed by the Academy:

Resolved, That it is sense of the Academy of Sciences:

First.—That the committee on pure food laws be authorized to continue its work.

Second.—That the committee co-operate with committees from other organizations in the enactment of pure food laws.

Third.—That the attention of the legislature be called to the necessity and value of pure food laws in this state.

Iowa as a state should not be surpassed by other states in the enactment of pure food laws.

The state should not remain an open field for imposing adulterated food products upon our citizens to the detriment of both health and pocketbooks.

Neighboring states are in advance of Iowa on this subject and the time is ripe for our state to take the position which rightly belongs to it in order that the citizens may be protected.

J. B. WEEMS,
C. O. BATES,
W. S. HENDRIXSON,
NICHOLAS KNIGHT,
MAURICE RICKER.

At the literary session the following papers were presented:

The presidential address, "The Relation of Physics to the Other Material Sciences."—A. A. Veblen.

1. "The Effect of Changes in Temperature on the Index of Refraction of a Gas when Heated at Constant Volume."—N. F. Smith. (Introduced by W. S. Hendrixson.)

2. "Forestry in Iowa."—B. Shimek.

3. "Some New Double Bromides and their Dissociation in Aqueous Solution."—Nicholas Knight

4. "Character of the Devonian Hiatus in the Continental Interior."—Charles R. Keyes.

5. "Evidences of Recent Uprisings of the Shores of the Black Sea."—Charles R. Keyes.

6. "Igneous Rocks of the Central Caucasus; and the Recent Work of Loewinson-Lessing."—Charles R Keyes.

7. "New and Interesting Species of the Flora of Iowa."—T. J. and M. F. L. Fitzpatrick.

8. "The Liliaceae of Iowa."—T. M. and M. F. L. Fitzpatrick.

9. "The Scrophulariacae of Iowa."—T. J. and M. F. L. Fitzpatrick.

10. "A Ruling Engine for making Zone-plates."—W. M. Boehm. (Introduced by A. A. Veblen.)

11. "Some Improved Laboratory Devices and Apparatus."—A. A. Veblen.

12. "A Study in Hereditary Transmission of the Papillary Finger Patterns."—A. A. Veblen.

13. "The Biological Station of the University of Montana."—Maurice Ricker.

14. "A Large Red Hydra."—Maurice Ricker.

15. "Nearctic Species of Acanthiidae."—H. E. Summers and Charlotte M. King.

16. "Nearctic Scutelleridae."—H. E. Summers.

17. "Notes on the Physiographic Ecology and Distribution of Plants in Western Iowa, Especially of the Loess."—L. H. Pammel.

18. "Notes on Ferns from Iowa and Western Wisconsin, and Southeastern Minnesota, Chiefly in the Herbarium of the Iowa State College."—L. H. Pammel and Charlotte M. King.

19. "A List of Plants Collected in Lee County, Florida."—A. S. Hitchcock.

20. "The Ustilaginae of Iowa."—H. H. Hume.

21. "The Sanitary Analyses of Some Iowa Deep Well Waters."—J. B. Weems.

22. "The Chemical Composition of Sewage of the Iowa State College Sewage Plant."—J. B. Weems, J. C. Brown and E. C. Myers.

23. "Menke's Method of Preparing Hyponitrites."—Alfred N. Cook.

24. "Calcium Carbide as a Dehydrating Agent for Alcohols."—Alfred N. Cook and A. L. Haines.

25. "The Sioux City Water Supply."—Alfred N. Cook and C. F. Eberly.

26. "On the Occurrence of Rhizopods in the Pella Beds in Iowa."—J. A. Udden.

27. "Pleuroptyx in the Iowa Coal Measures."—J. A. Udden.

28. "Factors in the Extinction of Animals."—Herbert Osborn.

29. "Analyses of Certain Clays Used in the Manufacture of Cedar Rapids Paving Brick."—C. O. Bates.

PRESIDENTIAL ADDRESS.

THE RELATION OF PHYSICS TO THE OTHER MATERIAL SCIENCES.

BY A. A. VEBLEN.

The last year or two of the nineteenth century and this first year of the twentieth have been prolific in literature dealing in one way or another with science topics. There have been addresses before learned and educational gatherings, articles in science journals, and in periodicals of well-nigh all kinds, much of all this writing having been produced by the masters and leaders of science; and the object of these productions has been, generally, to give a view of the present condition and importance of scientific work and knowledge, or to review recent progress either of science in general or of special departments. The condition of science at the beginning has been contrasted with that at the end of the century just past, or the greatest discoveries and most important researches have been passed in review, and the consequences that have followed have been appraised and estimated. The services of the great investigators, whose names adorn the pages of nineteenth century history, have been appreciatively explained, and the debt which humanity owes them has not been forgotten. The comforts and necessities we now possess, which were unknown a hundred years since, and which we owe to scientific discoveries and their application in practical affairs, have formed the burden of some of these writings.

Some of the boldest of this army of authors have ventured to prophesy as to the future of science; or they have discussed the problems which next are to be attacked and

solved by scientists, and have in some measure endeavored to foreshadow the manner of their solution.

Now, it goes without saying that much good has been accomplished by all this writing and the thought and discussion it has occasioned, and that from it benefits will accrue to us for many years to come.

Science workers themselves have been cheered and inspired by the enormous showing of results that has in this way been presented. The reviews of the difficulties overcome and the success achieved by our predecessors can not fail to strengthen and encourage us; and the essential unity and similarity of all the various and individual lines of research, as it becomes apparent to the thoughtful reader, must have cleared the mental horizon of many a hard working student of nature, who has been perplexed about the outcome of his own efforts.

To science men themselves, therefore, have come and are coming the first and most obvious benefits of the publications under consideration, especially in the proof that their efforts are well worth while, on the one hand, and on the other, in that by the aid of the discerning reviews made by the masters in their respective departments, they are enabled to take their bearings and establish their lines of orientation with greater certainty and confidence.

Perhaps no less important is the effect upon the mass of the non-scientific public, who have certainly come to see more clearly than ever before the debt which the race owes the indefatigable scientist, and who have thus come to place a higher value upon his work, to sympathize with him, and to assume an attitude of friendliness and become imbued with a desire to aid and comfort and applaud him. The cause of science education has already received an added impetus plainly traceable to this increased popular interest; and this is only the beginning of a movement which it cannot be doubted will be of large proportions and great benefit. Bequests and gifts for the endowment or establishment of schools of all grades and kinds, and of libraries and museums, and for the promotion of research, exploration, and discovery, are multiplying day by day and

surprise us by their munificence and freedom from hampering conditions. Governments and parliaments have felt the influence and have made enactments and appropriations greatly favoring and aiding the advancement of pure science and promoting the extension of the benefits resulting from its practical application to industrial affairs. It is especially pleasant to me to be able to speak my appreciation of the magnificent manner in which Congress responded to the appeal for a standardizing bureau, a movement which was set on foot, fostered and pushed by the science men of the country, and to which this academy gave its earnest, and, as it proved, most effective support and aid.

This same popular interest in science and science education has also loosened the purse-strings of many state legislatures and caused them to become more liberal toward their universities and other scientific schools and establishments. Our own law-givers, the men who officially reflect the popular disposition and give formal expression to the popular sentiment in our commonwealth, will honor themselves by dealing with our institutions of learning in a manner entirely befitting the dignity and wealth of the state, the standing of her scholars and science men, and the acknowledged eminence of her whole people in respect to intelligence and enterprise.

One matter suggested by this mass of writing on science progress, is the relationship and interdependence of the different sciences. This would however, form too vast a subject for a single short paper.

A sufficiently ambitious theme for the present occasion may be found in the relation of physics to the other branches of natural science, and her position among them, let us say, as a sister and servant. Noticing briefly some of the more salient and obvious points of contact, certain contrasts will doubtless become apparent, but in the main there will be found similarity and substantial identity in aims and methods.

Such a study, in which the aims of a large body of workers in a given line, their methods and standards, the

development of principles recognized by them as essential or fundamental, and the practical value of the results achieved by them, are reviewed or scanned, comparisons being made in these respects with the activity of those engaged in other and related departments of study, should result in considerable gain to all concerned. It should bring them together in mutual appreciation, and promote co-operation and sympathy. And if such an inquiry is carried out faithfully and thoroughly, it may be the means of preventing such waste of energy as surely takes place many a time because investigators lack knowledge of failure or success that has attended the employment of this or that method in other fields of work.

A conscious and consistent method of attack upon the problems presented in the study of any part or phase of nature's plan and operations, and the presence of a body of formulated principles and laws, which do not deny the regular operations of man's intelligence or the truthful action of his senses, may be taken as criteria by which any department of knowledge may be judged to have established itself as a science, or to have entered upon the beginning of its career as one. Judged on this basis physics certainly is one of the pioneer departments of science, and on this basis none can claim a higher and more honorable antiquity.

It appears that the earliest development of science was along physical rather than biological lines. Yet it would seem reasonable to expect that a systematic or exact study of the plants and animals, especially such as were essential to his very existence, would mark the first important step in man's entrance upon the condition known as civilized. This was probably the case; but it seems that this study was not carried beyond the requirements of immediate needs. Perhaps biological study was early tabooed, as too practical, and therefore vulgar. Man early became interested in the things farthest out of his reach; and astronomy perhaps must be considered the first branch of human research, if research is a proper term to apply to the

astronomy of the ancients. The positions and motions of the heavenly bodies were long observed and a mass of information about them accumulated and handed down. Theories were formulated about them; and plans of the universe were conceived. It was unfortunate that man began his scientific studies with astronomy; for he did not see things as they are, and the theories he formed were therefore all wrong. He carried his errors and false theories and unnatural conceptions in astronomy into his early study of terrestrial phenomena. The botany and zoology of antiquity were, like ancient astronomy, the results of observation. The habits of animals and the properties of plants were no doubt investigated with patience and accuracy; but as astronomy did not invite men to experimental tests, and as astronomers were perhaps the model and famous scientists of those times, it was perhaps too much to expect that methods independent of theirs should be developed in biological or natural history research. Whatever the cause, biology did not develop to any such extent as the opportunities for study would seem to warrant us in supposing. Astronomy had moreover the aid of mathematics, which in this science found useful and interesting applications. In physics the conditions were different. It was necessary that man should understand the laws of inamimate nature and be able to trace the connection between cause and effect, that he might be able to subjugate the animal kingdom, and in order to provide food and shelter and make his condition comfortable. As he advanced in his development these same motives led to more systematic and searching study; and mathematics found more obvious application than in biology. Mathematics might reasonably be expected to grow on the material furnished by astronomy and physics, while mathematics would in turn furnish solutions for new problems in the physical branches. Accordingly physics developed first along the lines of optics and mechanics. Without extensive and correct knowledge of physical laws and of the properties of matter, the wonder-

ful achievements of the ancients in the arts and industries would have been impossible.

Ancient chemistry was a cult rather than a science. It was a study in which influences of an occult and mysterious kind were invoked. It was largely a supernatural line of inquiry. And it was late before anything like a rational body of principles or laws was formulated. While chemistry or alchemy was the only department of study in which experiment played any important part, the experiments were devised not to exclude unknown and uncontrolled conditions, but rather to include as many unknown factors or agencies as could be brought into play. And experimentation on that basis would do little to promote discoveries.

What we know of the science of antiquity has come to us almost wholly from the Greeks. The Romans seem to have let pure science alone. In the middle ages there was of course some progress, but it was slow and tedious. There was no notable change in processes. The more ancient the method the more highly it was prized.

But the scientific method of the ancients was characterized by certain serious shortcomings, which were at least partly responsible for the painfully slow progress made among them. Men were in early times handicapped in a manner now difficult to appreciate, by a lack of most of the ingenious devices and instrumental aids to research which we possess. But if their methods had been right they would have acquired these means as men acquired them later, because modern scientific methods led to the discoveries which made these aids possible.

The science of antiquity grew by the often treacherous method of deduction, and by what we may by courtesy call observation. Such was the mental bondage of men at the close of the middle ages, that when observations revealed natural conditions which were at variance with the dicta of earlier authorities, the evidence was disregarded or discredited as being but deception of the senses, and the phenomena were frequently ascribed to the agency of the evil one.

Of course when men would not believe the evidence of their senses if it contradicted any of the standard authorities, there could be little scientific observation. And under such a despotic rule of authority experiment would be useless and would be calculated to bring men into trouble. It was when authority was deposed and experimental research was enthroned in its place, that modern science had its beginning. Four hundred years ago many men had begun to acknowledge the inadequacy of the old methods; and the real war of intellectual independence was waged during the century that followed. A long time was spent by men in striving to free themselves from the despotism of the ancient philosophers, which even after the seventeenth century claimed its victims, and sacrifices.

The pioneer army of modern science included many illustrious names, but no single leader can be said to have earned greater credit than Galileo. He lived and worked in the most critical period, saw most clearly the inadequacy of the old methods, and gave the most striking illustrations of the new processes. The importance of his experiments and discoveries and the principles he established and formulated were great enough to entitle him fairly to the name of the father of modern science. Though his brilliant astronomical discoveries made him immediately famous, it is what he did for physics that constitutes his chief claim to greatness and fame.

The experimental method, of which Galileo was the first conspicuous exponent, was the agency that gave new life to science progress. By it nature was made to allow the secrets of her processes to be laid bare, by being compelled to repeat them under restrictions and simplified conditions imposed by man. When the unequal weights, dropped from the Leaning Tower, were seen to strike the ground together, the old theory of gravitation was disproved, not because men saw the action of the experiment, but because the conditions were such that they were bound to trust the evidence of their own eyes. The experimental method

aided by mathematics rapidly extended the domain of physics; and physical methods were adopted in other lines of research. The apparatus and appliances of physics were borrowed and adopted in natural history, astronomy, and chemistry to their great advantage.

The knowledge gained of natural laws through laboratory methods led to inventions of new working devices, which in turn further extended man's power of research. Application of this knowledge to practical affairs followed closely.

New branches of science have been created by the extension and application of the new methods of research. Speaking of methods, we must not forget that they are in their general features identical for all the sciences; yet it is to be expected that the individual lines of scientific investigation must to a considerable extent differ among themselves in the minutiæ of their modes of work. Indeed, no line of research deserves the name of science until it has worked out methods somewhat distinct and characteristic, and its material aids and implements have begun to assume special and individual modifications.

By reason of its catholic and general character, and because it deals particularly with the more elementary and salient phenomena and natural laws, physics has necessarily developed methods of the most direct and simple type; and the devices and appliances of its invention are characterized by the same directness and simplicity; and in general the whole universe of science is indebted to physics for the invention and production of the elementary and essential mechanisms from which has been constructed its instrumental equipment.

It is certainly true of the early days of modern physics, that the problems attacked and solved, while difficult and formidable enough, were of a peculiarly simple and explicit character. And the genius with which great masters from Galileo to Franklin separated from the essential part of any research all that had none but an apparent connection with the principle to be sought out, fills us with wonder and compels our admiration. Doubtless the tasks of the

physicist have gradually assumed greater complexity, and his mechanical aids have become more and more intricate. But the same elementary directness of method, and the same ingenuity in discerning exactly what must be included in a line of inquiry, and what may be safely left out, have also distinguished the later physicists from Davy to Rowland.

The simple and elementary nature of physical research has no doubt also given character to the mental habits of the physicist. Concentration on such simple, definite problems as he deals with has tended to make him penetrating and critical in judging of the value of the evidence brought to light in research. He has set up for himself standards and adopted criteria as exacting and vigorous as those of the mathematician.

If I have been just and fair in drawing this outline sketch of the physicist, his field of work, his habits, methods and standards, it should represent the scientist in whatever department we look for him. It is indeed of the highest importance in any scientific inquiry that the investigator knows the exact scope of his problem, and is discriminating and unsparing in weighing the evidence that his search has found, in just the way here made out to be necessary for the physicist.

It seems to have been inevitable, however, that physics should have been the first of the material sciences to develop the modern methods of research and to provide modern aids. It was in the search for truth in regard to physical laws especially that men first broke away from the time honored servitude to the authority of the old philosophers, and added experiment to observation and mathematics, as the means of this search, and thus pointed the way for modern scientific progress in all lines of mental activity.

From prehistoric antiquity astronomers had patiently observed and handed down their data. Mathematics aided in the solution of the difficult problems that arose and the greatest intellects had formulated theories of the construction and mechanism of the universe. Yet little of

the truth was actually known. When, however, the methods of the new physics were adopted and the new appliances came into use, then the wonderful plan and vastness of material creation began to unfold itself to man. The alliance between astronomy and physics has grown closer, and striking and brilliant discoveries have resulted from it. Out of the physical laboratory have come the instrumental aids by which the astronomer reaches out into the confines of the infinite heavens.

Another study of physical laws and the results of their action on a grand scale and in almost hopeless intricacy and complication, is the physics of the earth, as geology now has come to be named. Eminently a science of very patient and discriminating observation, comparisons and classification, it was at a late day in the eighteenth century that it assumed a place as a respectable science. Geology draws with great freedom upon all other sciences for its aid. Physical laboratory methods find no great application, but familiarity with the principles and laws of physics are so much the more necessary here. The great length of time required for the processes he investigates, and the complex character of the evidence presented to him, demands of the geologist not only a clear knowledge of all forms of force and energy but an especially critical and discerning mental quality. And to attain or heighten this characteristic he needs thorough training in physics.

Chemistry is perhaps the nearest of kin to physics, both in respect to subject matter of investigation and in the minute accuracy of its processes. The boundary between their provinces is indefinite, and where physics ends and chemistry begins, it is often impossible to tell. The latter has become the more special and restricted both in methods and in the extent of its field. Chemistry, however, attained to the mental majority of a modern science much later than physics, and did so through the aids furnished by the physicists, and by assimilating their methods and adopting their standards of testing evidence.

The material equipment of the chemist is not only extensive but very special, yet most of his aids of the more general application were first employed by the physicist or came from his laboratory. Chemistry recognizes its relation to physics with characteristic clearness, and a large department of the science is given the name of chemical physics or physical chemistry.

The biological sciences form a group by themselves, and stand prominently contrasted with those so far passed in rapid review. There are, no doubt, great and organic differences between the biological and the physical sciences. But their general differences are often more purely apparent than real. Classification is generally a distinguishing feature of these, and this is their oldest inheritance, except perhaps, observation, that fundamental and most ancient process in all science study. Classification, which, of course, rests upon well-nigh endless comparison, is a feature more strongly in evidence in some of these branches than others; but it appears to the physicist that this is their distinguishing characteristic, as measurement is that of the physical branches. This does not imply that the one group does not employ measurement nor the other classification. It is simply intended to convey the idea of the general feature which is most accentuated in each group. When this is said, the essential difference has perhaps been stated. But these sciences employ more and more of experimentation and measurement, and their great discoveries are worked out in the laboratory; and of some of them this is as true as it is of physics and chemistry. Bacteriology is a laboratory product; and morphological inquiry is prosecuted by the most delicate and searching laboratory means.

But without the appliances which the chemist and especially the physicist have developed and elaborated for their own use, the biologists would practically lack the implements of their occupation. Their methods are largely identical with those of the former, but are more restricted and special in any given case. The criteria of evidence are the same as in the physical sciences; but in many cases,

probably because of the nature of the problems involved, the validity of a conclusion is established with greater difficulty and less certainty as to its correctness than in many a physical research, for instance. This is no doubt owing to the greater difficulty in arranging experiments that shall exclude all but a certain number or group of forces and agencies from the action to be observed. This condition calls for ingenuity of the highest order, and demands patience without limit. But this peculiarity of biological research emphasizes the need of frequently recurring to the consideration of physical methods of excluding from an experiment all but certain known and definite influences, and of the relentless rigor with which the physicist has been compelled to learn to cast out all evidence which can be at all called into question. As the biologist has advanced in the manner and direction here indicated he has penetrated deeper into those elusive unknowns which are of so much interest and concern to us, and which obscure the ever interesting problems in regard to the processes of life and the mechanism of vital actions.

The debt which physics owes to the other sciences is unquestionably great, whether regard is had to the material aids in research that have been borrowed by physicists, or whether one considers the problems furnished, or the suggestions of methods of work that have come from the discoveries, or even the failures of other investigators.

But physics stands in the relation of an elder sister to the other branches. This department of science has enjoyed the privilege of first establishing and defending the methods and criteria which must surely prevail until science shall undergo some radical and now unsuspected change in its essentials. Until such a time arrives, physics will continue to be at once the most severely exact of the sciences and the one among them whose privilege it is to lend and to give in the most unstinted measure both methods and means for their growth and perfection.

The object of all devotees of science is the same; truth — the truth in regard to nature, that nature and natural

system of which we are a small and humble part. A recent writer considers science not as a body of exact knowledge, but a "devotion to truth," the truth that is the object of search, and which is still unknown and undiscovered. The scientist is not a defender or guardian of truth; the truth that has been found and made known needs no defense nor does it require champions. The twentieth century scientist will indeed be devoted to the truth that is, but which he has not yet been able to search out, and which with the strength of his whole soul he strives to reach.

Such then is science, a vocation, a devotion of one's self to that which alone is worth while. And the scientist has consecrated himself to this unknown truth. In this conception of science, and scientists, there can scarcely be degrees of merit, nor can the searchers after any form or manifestation of truth claim greater merit than those seeking some other form of it. All are equally noble, and all departments of science must be equally free and generous with their aid to any other branch, to further its object and to cheer its devotees.

SOME IMPROVED LABORATORY DEVICES AND APPARATUS.

BY A. A. VEBLEN.

A MODEL TO SHOW THE TRANSMISSION OF A WAVE BY TRANSVERSE VIBRATIONS.

The base of the model is a plain board 26 by 9 inches. At the rear edge of this is another board 5 inches wide, set on edge, A, Fig. 1. To the upper edge of the latter are hinged 27 metal rods A D, 8 inches long. The front ends of the rods are free to move up and down in vertical slots C, and each carries a white disc D half an inch in diameter, which is soldered at its center to the end of the rod, and at right angles with it. Approximately simple harmonic motion is imparted to these discs, so that they represent the vibrations of the particles of an elastic medium transmitting a simple transverse wave motion. The mechanism for producing the motions of the discs is the following: A round half-inch steel shaft is mounted in bearings at the ends. Upon this shaft are 27 eccentrics, one of which is shown in Fig. 2. These are loose upon the shaft, except the first one, which is fastened to it. On one side of each eccentric are two short pins, or brads P P, 40 degrees apart, reckoning the angle about the axis of the shaft as a center. On the opposite face of the eccentric is a single stop T, bisecting the 40 degree angle between the brads, and consisting of a small wire staple driven in so as to protrude the same distance as the brads just mentioned. The eccentrics were made by sawing a two-inch curtain pole into three quarter-inch lengths, and boring half-inch holes for the shaft, S, Fig. 2. Besides the eccentrics the shaft also has upon it a loose wheel with a groove in its periphery, Fig. 3. Fig. 4 gives a side view. Over the wheel and in the groove, passes a string, one end of which is fastened to a

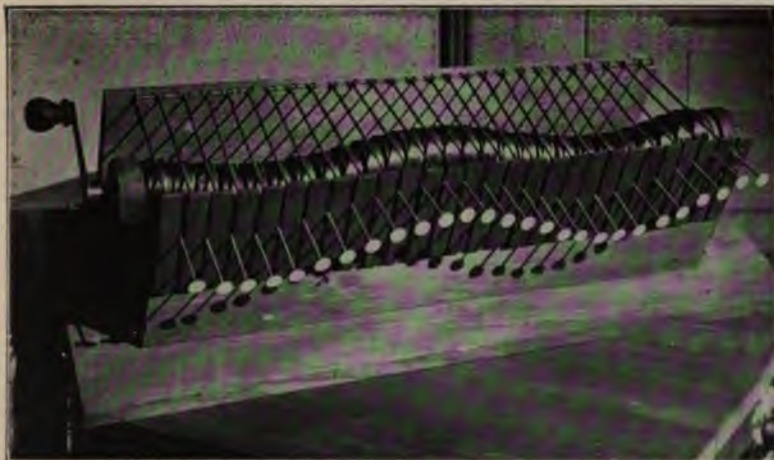


Figure 1. Model to show the transmission of a wave by transverse vibrations.

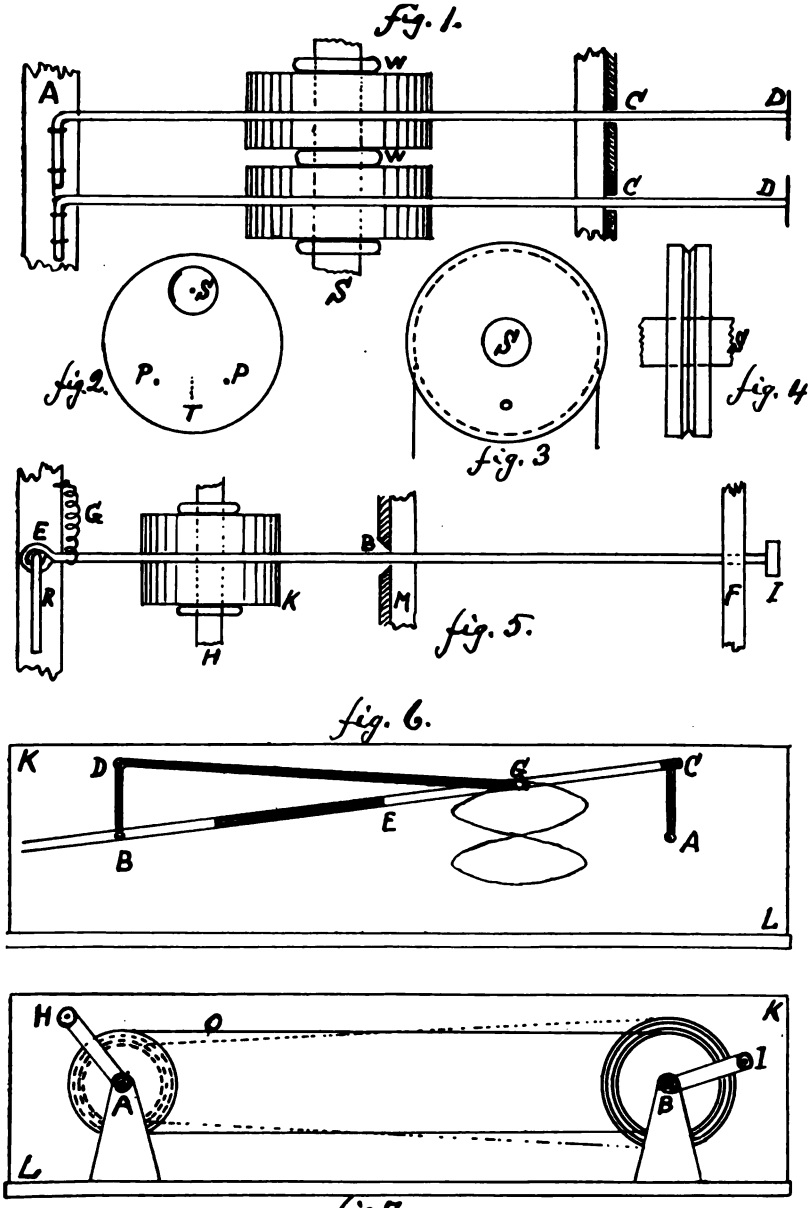
Figure 2. Model illustrating the longitudinal or sound wave.

hook in the base of the model. The other end is tied to an elastic band, and this in turn is fastened to another hook in the base. The string being short enough to be under considerable tension from the stretching of the elastic, acts as a brake upon the grooved wheel and allows it to turn only against more or less friction. The eccentrics are separated by washers or rings W, of sufficient thickness to prevent the brads and staples from touching the faces of the eccentrics opposite. On turning the shaft by the crank at one end, the first eccentric, being fast on the shaft, will after turning 20 degrees, or until one of its pins P, engages the stop T, on the second eccentric, cause this to turn with it until it in its turn carries with it the third. Finally the last eccentric will be set revolving, and will carry with it the grooved wheel, against the friction of the string. This brake prevents irregularity in the motion of the last eccentrics on the shaft. The eccentrics now revolve together, but each one is 20 degrees earlier in phase than the one just ahead. As there are 27 of them they assume an arrangement like a screw of long pitch whose thread makes a turn and a half from one end to the other. The rods which carry the 27 discs D, are so spaced that each rests on a corresponding eccentric, and transversely to the shaft. As these revolve, the free ends of the rods, with the discs, describe vertical simple harmonic motions differing in phase by successive intervals of 20 degrees. The effect of these motions is to produce a sinusoidal wave motion of the discs, which may be taken to represent individual, equidistant particles of a medium transmitting a wave by transverse oscillations. The motion may be stopped and started at any instant or made as rapid or as slow as may be wished. The particles may be brought into a straight line, representing the medium at rest, by reversing the motion a turn and a half. The model is especially useful in elementary instruction, and represents in a plain way the mechanism of this class of wave motion, without departing seriously from theoretical exactness. Its novelty consists chiefly in the application of the loose eccentrics on a shaft. Any phase difference, and any amplitude, may

be provided for by varying the proportions of the parts. It is desirable in practice to include somewhat more than one wave length. This model includes one and a half. The front of the model is painted black so as to set off, with sufficient contrast, the discs, which are white.

A MODEL ILLUSTRATING THE LONGITUDINAL OR SOUND WAVE

This model is about 13 inches wide by 36 inches long. At its back is a five inch board E, Fig. 5, set on edge and extending nearly the whole length of the model. Driven into the upper edge of this board at intervals of one inch are 27 straight, smooth wires, or small rods, R, two inches long, inclined to the left, say, at about 45 degrees from the vertical. Another 5 inch board M stands on edge about the middle line of the model. To the edge of this board are fastened thin strips, inclined, so as to form 27 slots leaning to the right about 45 degrees. In a third board F standing on edge at the front of the model is a horizontal slot 30 inches long, 5 inches from the base. A small rod or stout wire E I, Fig. 5, bent so as to have an eye or loop E at one end and carrying a half inch disc at the other end I, passes through the horizontal slot in F, and through an inclined slot B, while the loop E encircles an inclined rod R. A light spiral spring G fastened to the side of the board so as to have the same angle of inclination as R, produces gentle tension on the rod against or toward the upper edge of the board. There are 27 rods like EI. It will be seen that if a rod be grasped between E and B and raised, the loop E will swing toward the left as it rises along R while its middle point will move to the right in moving up in the slot B, which leans to the right. I will therefore move toward the right, as viewed from the front. On letting the rod drop, motions in the opposite direction will take place at E and B; and I will move back toward the left. If now a point on the rod between E and B describe simple harmonic motion up and down, I will describe the same kind of motion horizontally. The up and down motion of the 27 rods is produced by a shaft H with 27 eccentrics K under the rods and between the upright boards E and M. The



Harmonic motion model.

shaft, eccentrics, washers, brake, etc. are exactly like the driving mechanism detailed in the description of the model for the transvers wave motion. The length of the eccentrics K upon the shaft H is greater in this model than in the other, chiefly because it is desirable to separate the discs I farther than the discs in the former model described.

The limit of motion of each eccentric being 20 degrees with respect to the one next to it, the harmonic motions of the discs I will differ by intervals of 20 degrees difference of phase. The model therefore represents a longitudinal or sound wave, and includes a wave length and a half. But the phase differences could be made different by choosing different angles between the pins in the eccentrics. The degree of compression and rarefaction in the wave will depend on the "throw" of the eccentrics and other proportions of the model. The chief usefulness of this model, as of the other, consists in the simplicity of the mechanism, and the perfect control which the operator has over the motions.

The models can be made with very meager shop facilities. Anyone who sets about making them will easily apply improvements in the devices. The contrivance of the loose eccentrics on a shaft is probably susceptible of being adapted to other illustrations of wave motion.

A MODEL FOR COMPOUNDING SIMPLE HARMONIC MOTIONS.

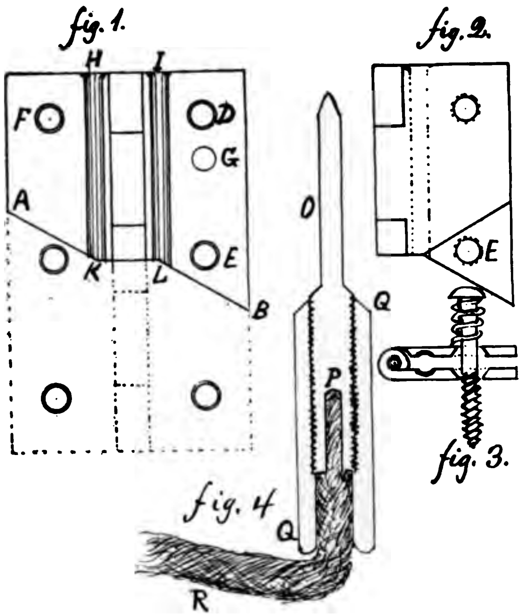
In teaching the properties of simple harmonic motion it is desirable to show in an elementary manner how two such motions, when compounded, will produce the beautiful figures shown by the method of Lissajous. But when the tuning forks are used the actual tracing of curves cannot be watched. The resultant is all that can be shown. In addition to the tuning forks of Lissajous and various contrivances, employing pendulums, the stereopticon, and the like, a contrivance is useful which will trace the figures so slowly that their production may be watched by a whole class, and which may be stopped, and started again at any point to take up the tracing where it was stopped, without spoiling the continuity or regularity of the curve.

A simple and satisfactory model of this kind is here described. On one side of a board KL, Figs. 6 and 7, about 40 by 7 inches, and standing on edge upon a second board which serves as a base, are two pulley cones with four (grooved) steps on each; and these are so proportioned that when a belt or endless cord O passes over corresponding pulleys in the two cones their relative angular velocities will be in the ratios 1:1, 3:4, 2:3, or 1:2. Upon the axes of these cones, and revolving with them, but on the other, or front, side of the board KL, are two cranks AC and BD. A connecting rod BEC actuated by one crank, AC, slides horizontally upon the shaft B of the other crank, being slotted at the end B for this purpose. Another rod DG actuated by the crank BD has at one end, G, a sleeve which slides in the long slot EG of the other rod. A pencil, at right angles to the upright board, and carried in this sleeve, G, traces the curve upon a sheet held or pinned against the front of the board. To press the pencil against the paper a rubber band may be passed around the outer end of the pencil and the end of the rod at G.

With the belt thrown off the pulleys, it may be shown that the crank AC alone produces harmonic motion in a vertical line; and that the crank DB produces horizontal harmonic motion. And it is plain that the curve traced when both cranks revolve is the resultant of both these motions.

If the radii of the pulleys are not exactly in the simple ratios 1:1, etc., the model is the more instructive as it shows the mechanism of the progressive motion or revolution of the curves produced by tuning forks in the similar case. The fact that the curves are slightly distorted because the right and left motion of G departs from a strictly horizontal direction in the upper and lower positions of C does not detract from the usefulness of the model. The longer the model is in proportion to the lengths of the cranks, the smaller will this distortion become.

In Fig. 7, the belt is on the two equal pulleys, or the two motions are in unison. If the belt be in the position shown by the dotted line the model produces the curve of the two



Cable switchboard.

Cable switchboard. View of one jack mounted in the switchboard, with a plug inserted. The front panel is partly cut away.

motions differing in frequency by an octave. One variety of this curve is shown in Fig. 6.

A SIMPLE AND EFFICIENT CABLE SWITCH BOARD.

A serviceable, cheap, and easily constructed switch board, which has been in use for several years, has a jack of novel design. These jacks are, in the switch board in question, mounted on a wooden frame. This is proper enough where the circuits terminating in the board are subjected to pressures of only a few volts, as in connecting batteries and apparatus for the ordinary purposes of a physical laboratory. But where an indestructible board is required, the jacks in question can readily be mounted on slate or marble.

To make the jack, take a common heavy brass hinge three inches wide, and cut it in two like halves along the line AKLB, Fig. 1. Now fold the leaves of one-half together until they are parallel, clamp it in a hand-vise, with a plate of proper thickness between the edges of the leaves. With a drill three-sixteenths inch in diameter bore the hinge out near the joint, so as to make the channels HK and IL, to receive the round plug of the cable, which is to be used in connecting different jacks in the switch board. Bore the extra hole G. The jacks may be mounted upon horizontal bars forming the frame-work of the board. A screw is driven through the hole A so as to fasten the jack down to the bar, with the end I nearly flush with its front edge. A round headed screw in G will serve to keep the leaf AH from closing down too closely upon BI, but leave room for the easy insertion of the plug.

Another screw through E will also serve to fasten the jack to the bar. The terminal of the circuit coming to this jack may be clamped to the hinge by the same screw. The hinge is now closed by folding the opposite leaf over. A spiral spring of a few turns of spring brass wire is slipped on a rather long screw, which is then driven through the holes F and D, into the wood, until the spiral spring presses the upper leaf of the hinge down firmly. See Fig. 3. The jack is now complete.

To make the plug, take a brass rod about 3.5 inches long and, say, $\frac{3}{8}$ inch in diameter. Turn one-half of it down to the size of the drill used in boring out the channels in the jack; point the end neatly. See Fig. 4, O. Thread the other half with a rather coarse screw thread. Also with a drill about one-eighth inch thick bore a hole a half or three-quarters of an inch deep in this end; P, Fig. 4. The end of the cable R is stripped and soldered into the hole P. To make the handle for the cable take a piece of thick walled, hard rubber tubing about two inches long, tap it out to fit the thread upon the plug, finish it neatly, and screw it on the plug into the position Q, Q. The other end of the cable is finished in the same way. It is advantageous to slip the handle Q on the cable before the latter is soldered in to the plug. The cables must, of course, be long enough to reach between the jacks farthest apart in the board. In the board constructed, 100 jacks are arranged in ten rows, and occupy a space about 30 by 40 inches.

The front of the board is protected by thin panels, with holes corresponding to the channels in the jacks, and admitting the plugs.

When this style of jack is to be used in a fire-proof switch board, the back of the board may be a slate slab to which may be bolted small brackets or right angle pieces of brass, upon which the jacks may be fastened in almost identically the same manner as when wood is used. The bolt, or bolts, by which the brackets are fastened to the slate may serve also to connect the terminals of the circuits to the jacks. The front of such a board may be protected by panels of marble or slate, with holes properly located for the admission of the plugs to the jacks.

A CAMERA TABLE.

By a camera table is here meant a device by which an ordinary camera is conveniently mounted for photography for scientific purposes, such as enlarging or reducing cuts, charts, etc., for lantern slides or for illustrations to be used in the class room, in note books, and the like; or for

photographing small objects, such as pieces of apparatus, and botanical, zoological, and geological specimens.

The table proper is 7 feet long by 24 inches wide, and 27 inches high, and is mounted on substantial two-wheeled casters. The framework consists of two pieces, S, Fig. 1, 1 by 5 inches, and 7 feet long, for the sides; four cross pieces, Q, 2 by 5 by 17 inches; and the four legs L, 2 by 3 inches, bolted on near the ends of S, and spreading somewhat so as to give greater stability. The top consists of two thin boards of such width as to leave an opening or slot, three-quarters of an inch wide, in the middle and running the whole length of the table. On the outside of the side pieces are two rails, R, one (on the left) being flat, the other having a ridge above. Upon these rails slide the movable parts to be described. The ridged rail at the right serves as a guide. The other rail, being flat, allows the sliding parts to adjust themselves without binding, from unequal expansion of the parts.

The cross pieces of the frame are partly cut away under the central slot, as shown at E, so as to allow the clamps attached to the movable parts to move freely in the slot.

The stand or pillar, on which the camera K is mounted is fastened to the base U, which can slide sidewise between guides at the front and back as a sub-base V, about 20 by 23 inches. It lies on the cleats W, which rest on the rails R, upon which the whole may slide along the table. The pillar may be firmly clamped to the table by tightening the nut C, which raises the clamping screw that passes through a transverse slot in U, a hole in V and the opening in the table top. The screw is attached, below, to the clamp which consists of a piece of wood about 6 inches long and having the cross section shown above E.

The pillar itself is adjustable in height. It consists of two parts. The inner part I, being raised or lowered by the large screw D, which passes through the nut N attached to the movable portion I, I. To promote rigidity in this structure it is made triangular in section, and when adjusted to the proper height it may be clamped firmly by the three-way clamping device shown in cross section

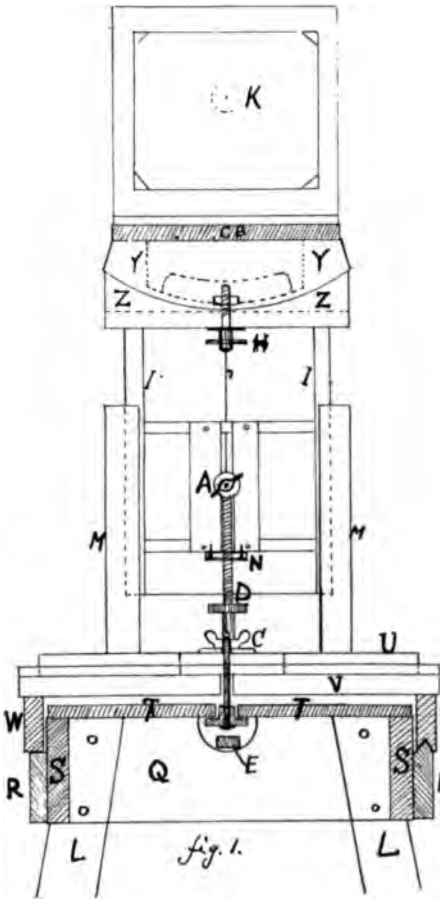
through A. See Fig. 2. M, M are the sides of the fixed portion of the pillar. I, I are the sides of the movable parts. The bolts X, X are screwed into a hexagonal ring or collar, and pass through holes in M and vertical slots in I. The clamping screw A is attached to the same collar. Tightening the thumb-nut A clamps I, I firmly against M, M.

On the top of this triangular pillar is a device for further adjusting the camera by revolving it about the axis of the lens. This is effected by placing the camera K (see Fig. 1) on a base CB whose curved supports Y (one at each end of the camera base) slide upon a sub-base, fixed on top of the pillar and having end pieces Z curved to receive Y. Cleats on Z prevent Y from displacement forward and backward. The center of curvature of Z and Y is in the axis of the lens. When the adjustment of the camera about its axis has been made, the base CB is clamped by the screw H, which engages a slotted plate of metal of the same curvature as Y.

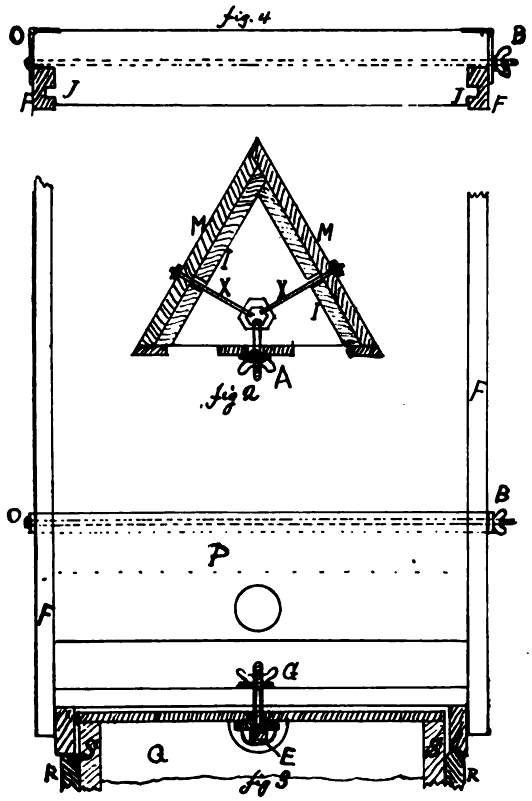
The object to be photographed is mounted on the rack or holder shown in Fig. 3. It consists of two uprights F standing on a base 20 by 33 inches which rests upon the rails R, and slides on them the same way as the camera stand already described. If a drawing is to be copied, it is pinned on a board 22 by 20 inches which rests in grooves in the uprights F and is held up by the support P which can be clamped at any height by the clamping device BO. The construction of this clamp is shown in cross section in Fig. 4. The rod BO, by pressure of the thumb nut B causes the hinged plates at the ends to grasp the uprights FF on the outside. The top of the support forms a shelf OJJ on which small objects may be placed while being photographed. The board P, which forms part of the adjustable support, slides up and down in the grooves J of the uprights.

This whole rack or holder may be clamped to the table by the clamp G, which slides with it in the longitudinal slot. Besides being a clamp this contrivance, when the

Camera table.



Camera table.



Camera.

nut G is released, serves to enable the operator to move the object holder along the table, by means of a rod E lying under the slot. This clamp, like the one at C, Fig. 1, consists of a piece of wood about six or eight inches long. It has a cross section somewhat resembling an inverted capital T, as shown just above E, Fig. 3. The tongue projecting up into the slot keeps the clamp in alignment. The screw or bolt G passes through the body of the clamp and up through a hole in the base of the object holder. And when the latter is to be clamped fast the nut is simply tightened down. During the process of adjustment the nut is kept loosened so that the clamp may slide freely in and under the slot. The rod E by which the operator moves the clamp, and with it the object holder, is oblong in cross section. It lies under the slot in the table top and reaches the whole length of the table. Screwed to the under side of the body of the clamp is a loop of plate brass; and in Fig. 3 the rod E lies, thrust loosely through this loop. If it be now twisted some 40 degrees it will bind in the brass loop and so engage the clamp. The latter, with the object holder, can then be drawn back or thrust forward at the will of the operator. The rod may be disengaged from the clamp by a turn of the hand, and may be left, pushed in under the table, out of the way, when the adjustments are finished.

By the arrangements here described all adjustments of the camera and object may be made without removing one's head from under the focusing cloth. Any one who has used a camera for the purposes mentioned here knows that all the adjustments of this apparatus are desirable. First, the object to be photographed is placed approximately in the right position on the object holder. The exact vertical and horizontal adjustments are next made; and finally any fault in the orientation of the image on the ground glass is corrected by revolving the camera about the axis of the lens. When the image is of the right magnitude and in proper position the movable parts are fastened in their positions by the clamping screws or nuts.

A STUDY IN THE HEREDITARY TRANSMISSION OF FINGER PATTERNS.

BY A. A. VEBLEN.

By finger patterns is meant figures formed by the minute papillary ridges upon the inside surface of the last joint of the thumb and fingers. They are most conveniently studied by inking the fingers with printer's ink and making impressions on paper or any smooth light surface to which the ink will adhere. Sir Francis Galton in his work "Finger Prints" and other publications, treats the subject of these patterns exhaustively and scientifically. The patterns are of practically infinite variety. They are also persistent and unchanging through the life of the individual, and are destroyed or obliterated only by violent and deep injuries to the fingers. Finger prints therefore constitute a certain and convenient means of personal identification. Though the patterns differ so much on different fingers, they may be classified under three general types, called the arch, the loop, and whorl. In the arch the lines or ridges run in a more or less regular transverse arrangement across the finger tip. In the loop the characteristic portion of the pattern is enclosed in a gulf-like or bay-like arrangement of ridges. The bay may open toward the thumb or the little finger side of the hand, or to the radial or the ulnar side. In the present discussion we shall use the terms as Galton uses them, calling these loops ulnar or radial according to the side toward which they open. When the ridges in the characteristic portion of the pattern assume a spiral or circular, or twisted arrangement, they are said to form a whorl. In a very few patterns the arrangement of lines is so irregular or anomalous as to make it difficult to decide as to their classification; but such cases are much rarer than might be expected.

Arch. Loop. Whorl.
Figure 1. Finger patterns.

It is found that 6.5 per cent of all patterns are arches; 26 per cent are whorls; and 67.5 per cent are loops. A combination of symbols or letters denoting the class of pattern on each of the digits of an individual is called the formula of his prints. The letters used are a, l, w, for arch, loop, and whorl; and u and r are used to indicate ulnar and radial loops, particularly on the index fingers. A very large number of such formulas is possible. Some of them are much more frequent than others.

Galton devotes a chapter to the question of heredity in finger prints. He finds a "decided tendency to hereditary transmission"; and his investigations point to a preponderance of maternal over paternal influence. One method pursued by him is to note the frequency of the occurence of patterns of the same class upon the same finger of the hands of parents and their children.

By a process differing somewhat from Galton's method, I have found what seems a clear case of hereditary influence on finger patterns. The case is that of the family of Mr. and Mrs. A, as we will call them here.

I have their finger prints and those of their eight living children and thirty of their grandchildren, as well as of the husbands and wives of the children, and of a few other relatives. Mr. A has loops on all ten digits, all opening to the ulnar side. His formula would be ull ull ll ll; which by the way is one of the most common formulas to be found. The patterns are small and very regular. Mrs. A has seven whorls and three loops, all large patterns. One son has nine loops and one whorl. The three other sons and the four daughters all have the same formulas as the father; or they have nothing but loops. Their patterns are very regular, but generally larger than those of the father.

One of the daughters, I, whose husband has 7 whorls and 3 loops, has five children who have altogether 12 whorls and 38 loops; or 76 per cent of all their prints are loops. One son, N, whose wife has 6 whorls and four loops, has eight children whose prints show 3 arches, 16 whorls and 61 loops. 76.25 per cent of their patterns are therefore

loops. A daughter, M, has six children with 2, 11 and 47 arches, whorls and loops respectively; or 78.3 per cent of loops. The father of these children has 1 arch, 3 whorls and 6 loops. He is the brother of N's wife; and I have the prints of the fingers of two of their sisters. These four members of that family have 62.5 per cent of loops, which is slightly less than the average number of loops among all prints. These four have 2 arches, 13 whorls and 25 loops. They do not show any decided family tendency to depart from the normal distribution of prints.

Another daughter, B, of Mr. and Mrs. A, has eight children who have 11 arches, 2 whorls and 67 loops. 83.75 per cent of their patterns are loops. B's husband also has 10 loops. H, the fourth daughter of the A's has three children, two of whom have 2 whorls and 8 loops each; but the third has 9 whorls and only 1 loop. The percentage of loops among these children is therefore only 57 which is lower than that of any of the other groups of grandchildren. The father of these three children has 2 whorls and 8 loops.

The thirty grandchildren have 16 arches, 54 whorls and 230 loops; 76.7 per cent of their prints are loops; which is an excess of 9.2 per cent over the normal. They are quite deficient in arches, except in the cases of two individuals, and they are somewhat deficient in whorls. Arches occur but rarely in most of the families into which the children of the A's have married.

Mr. A has a brother who has 9 loops and 1 pattern which may be called a loop with a very small whorl within it.

A half brother of Mrs. A had 10 loops. He was married to a sister of the wife of N and of the husband of M, she having 1 arch, 1 whorl and 8 loops. Prints from five of their children reveal 1 arch, 1 whorl and 48 loops, or 96 per cent of loops.

The number of radial loops is noticeably small in the children and grandchildren of the A's; except the children of B, whose husband has radial loops on his index fingers. Among their eight children are 4 radial loops on index fingers.

There is information at hand which points to an excess of loops in the families of both Mr. and Mrs. A. But relying simply on the records contained in the prints from the persons here mentioned, there seems to be good reason to conclude that there is a decided tendency to hereditary transmission of the type or general class of patterns. This is further supported by resemblances in the lesser characteristics of the patterns studied, such as their general regularity, the fineness of lines, slope and size of the loops, the sub-class of whorls where they occur, and the general symmetry of the prints. When these are considered it appears fairly certain that a decided family likeness in finger patterns is transmitted to the children and the grandchildren.

FACTORS OF EXTINCTION.

BY HERBERT OSBORN.

While we have come to recognize clearly the fact of extinction of animal types and their replacement by other forms of life there appears to have been less attention to the special factors concerned in such extinction, or, to put it differently we have been devoting our attention especially to the factors concerned in the production of new types, the variation and evolution of animals, rather than the factors of extinction. It is true that these may bear a close relationship and present mutual dependencies and possibly we might take them as necessary corollaries or consider factors of extinction as merely negative factors of evolution, but it seems to me worth while to attempt a distinct formulation of those factors especially concerned in the elimination of life forms even if for no other purpose than to emphasize those factors of progressive evolution against which they contrast.

In the first place there is a certain kind of elimination which can hardly be called extinction in the proper sense. I refer to the progressive evolution by which a particular

form is evolved into a more highly organized or specialized one. In the course of time the species, possibly the genus, has become entirely replaced by the more modern type, but to say that the earlier forms have become extinct is merely to recognize their gradual transmutation into the later form. If representatives of the older type persist and are finally pushed to the wall by the newer one we must still recognize that there is a chain in the direct line of descent for the newer type in which extinction is not the proper or at least the most significant term. Eohippus, Orohippus, Mesohippus, Protohippus must be looked upon as links in an ancestral chain individually extinct but represented in the modern horse; that is, a persistent type. The Ammonites on the other hand furnish an example of an extinct type. "Extinction" in the one case is certainly a very different thing from what it is in the other. The former is evolution not extermination or elimination of the type.

Direct evolution is perhaps the prime factor in the dropping behind of particular forms of animal life, extincion as we have been accustomed to call it.

Of factors causing total elimination of a form or type of life we may note first; changes in the physical environment as these are perhaps the more certain and widespread in effect. It should be noted of course that certain forms may respond to such changes and by rapid evolution adapt themselves to the change when they would fall into the preceding category, but there have been undoubted cases where over an extensive area the changes have been so radical and rapid as to obliterate a certain kind of fauna.

For example the obliteration of cretaceous seas of central North America, the present plains region of the west, was accompanied by the extinction of a host of marine forms which seem neither to have escaped to other parts of the ocean or to have evolved into any other form fitted for terrestrial or fresh water existence. Striking among these are the Baculites, Ammonites and other Tetrabranch Cephalopods; also a large contingent of marine saurians.

It is perhaps unsafe to assert that other factors may not have come in as the immediate agents in extermination when the animals had reached a state of decadence due to unfavorable environment, but so far as we can see the continuance of cretaceous conditions would have permitted the survival of some at least of its characteristic fauna.

While the change in this instance was one of elevation of land surface and obliteration of ocean we can suppose similar destruction of land fauna by the submergence of land areas. In fact we have pretty strong evidence for particular cases of extinction during quaternary times as a result of extensive submergences. Even in marine life depression if taking place more rapidly than adaptation can follow must result in extermination. Corals limited to certain depths are killed by submergences to lower depths and for species limited to certain areas extinction of the species would result.

Encroachments of seas upon the land or land upon the seas may each result in destruction of life, possibly the extinction of species though usually such changes are too slow to result in complete extermination. They result rather in migration or variation.

Advance of polar ice cap and its subsequent retreat has very probably resulted in some extinctions particularly among animals of fixed habit.

Changes of climate from humid to desert or hot to cold in any area if occuring rapidly would certainly influence the fauna and possibly result in extinction.

Competition among related forms or among forms requiring similar conditions has perhaps been most commonly recognized as a factor in extinction. The "survival of the fittest" is here most strikingly illustrated and observation on existing forms leads to more ready appreciation of its force. Closely related species struggle for mastery in a limited area and one of them is crowded out, or, species in widely separated groups may be thrown into competition in a particular region and one or the other must give way. The Indian gives way to his white competitor, the wild

animals inimical to man are driven out and operations of similar nature doubtless occurred among lower forms before man appeared upon the earth.

Such competition may have arisen between forms indigenous to a particular region but is evidently most striking when species of different faunæ are brought into contact as when from migration a species is introduced to a new locality. European butterflies, sparrows, and other forms including man brought to America by design or accident, are prone to supplant the native species. Such migrations and consequent competitions we can safely assume to have occurred in prehistoric as well as in historic times and that species have been exterminated thereby we can scarcely doubt.

The opening of some barrier permitting the projection of one fauna upon another would intensify such action producing for a number of forms the conditions that ordinarily occur accidentally. Thus the establishment of land connection between Europe and America permitting migrations of whole faunas and their intermingling has resulted in intense competition. Asiatic and African faunas have probably been projected upon European and rapid evolution of European types is thus explained. Lack of such connection and competition may account in part for the conservatism of the Australian fauna.

Quite different from these it appears to me is the extinction which follows some extreme specialization which has fitted the animal to some very limited sphere of existence. For example, parasitic animals have acquired such a dependence upon a host form that extinction without this host is inevitable. Extermination of the Great Auk doubtless carried with it extermination of the parasites peculiar to that species. Further, the parasites dependent on two or more hosts must be exterminated by the destruction of one of such hosts.

The liver fluke is doomed to extinction whenever one of its necessary hosts is wanting or even whenever the necessary association on common ground of its essential hosts becomes impossible. What occurs locally would be gen-

eral and the species would be totally exterminated if such separation could be made to cover all points where the species occurs.

Other cases of extreme specialization are to be found among those forms that have adapted themselves to desert conditions and which can hardly be conceived as having the possibility of survival if forced back into humid conditions with competition with forms of life of more general character. The cave animals cannot survive under ordinary conditions of light and outer air. Subterranean animals must have their peculiar environment or perish and deep sea animals are totally inadequate to the more general conditions prevailing at shore line or in the shallow reaches of the sea. Some of our domestic animals are practically dependent on man, some species of flies depend solely on their resemblance to certain bees to get entrance to nests and stores of food, while certain ants which have adopted slaveholding are said to be entirely unable to carry on the ordinary duties of the colony but are dependent upon their slaves for their very existence. So, too, some species of insects are dependent on a particular food plant and will perish without it.

Specialization in such cases means a kind of limitation and total unfitness for existence outside of certain conditions and hence extinction if those conditions fail. Possibly we might call this a form of change in environment but it must certainly rank as a special form of environmental change.

This differs essentially in the fact that such forms have in a certain way selected the route along which they have traveled and thus foredoomed themselves to extinction. In every case we must assume that such extremely specialized forms have been derived from more normal or generalized forms; parasitic from free forms; desert forms from those occurring in more humid regions; cave forms from those occurring above ground; deep sea from surface or shallow water species, and so on, and that the occupation of the particular niche in nature has been one of selection

on the part of the animal or rather of some members of its ancestral line.

Finally there is the form of elimination which occurs apparently as the termination of a long course of gradual decadence or senility and in which distinct elements of destruction are difficult to discover. A process which we may designate as exhaustion. It may be compared perhaps to that running out or deterioration which cultivators recognize in a variety or race that has been kept through a long course of generations. Such exhaustion appears to occur in certain protozoans as paramoecium after a period of fission and which seems to be counteracted by the process of conjugation. Upon such a basis as this we may account for the disappearance of certain types of animal life which so far as we can see have not been forced out by the other factors. Or it might be looked upon as a protoplasmic exhaustion which rendered the type susceptible to the action of other factors or a combination of factors no one of which could be counted as predominant.

To summarize these factors then we may recognize:

First.—That extinction which comes from modification or progressive evolution; a relegation to the past as a result of the transmutation into more advanced forms.

Second.—Extinction from changes of physical environment which outrun the powers of adaptation.

Third.—The extinction which results from competition.

Fourth.—The extinction from extreme specialization and limitation to special conditions the loss of which means extinction.

Fifth.—Extinction as a result of exhaustion.

I realize that these groups do not represent a classification based on hard and fast lines and such groups are seldom found in nature but it seems to me that they indicate in a tentative way what may be recognized as a number of quite different processes by which organic groups may suffer disappearance.

FORESTRY IN IOWA.

BY B. SHIMEK.

A paper on forestry in Iowa might be condensed in the form of a paraphrase of the schoolboy's essay on "Snakes in Ireland,"—"there is no forestry in Iowa,"—at least none in practice, though the need of the practical application of its principles may be seen in every township of land in the state.

Fifteen or twenty years ago the total forest area of Iowa probably exceeded the area covered by the original native groves which sheltered the first settlers who saw in them the only hope of future happy homes. The restriction of prairie fires, the removal of the larger trees and the general artificial improvement of the conditions under which plants grow, all tended to extend the native groves beyond their original bounds, and it appeared for a time as if a large part of the state might ultimately be clothed with forest growth. But the population of the state, and the value of its lands, increased at a remarkable rate, for the experiment of the settlers who first ventured out upon the prairies and who reaped rich harvests in return, proved eminently successful.

Iowa lands were rapidly taken up, and there was a revulsion of sentiment against the timber and in favor of the prairie. Even the hilliest, poorest land was regarded as more valuable for agricultural purposes and pasture than for timber, and the groves rapidly disappeared, and are still disappearing, in many sections, to be replaced by poor pastures or still poorer farms, while comparatively less effort has been made to extend the artificial groves on the prairies. The temptation to destroy the original groves was increased by the fact that, while the legislature made

provision for encouraging the planting of trees on the prairies, nothing was done to tempt land owners to preserve the native groves upon their lands. To add to the destruction a succession of dry seasons drained the wet lowlands which had formerly been used for pastures, and they became the richest farming lands. The cattle were turned into the groves, to which their presence proved fatal even where the owners did not assist in the process of clearing. The original groves were for the most part upon the slopes adjacent to streams. When they were cleared away the leaf mould and fine soil, and even much of the harder subsoil, were washed from the exposed surfaces into the streams. The trees no longer conserved moisture and the springs disappeared; the rains swept the bare hillsides, the waters rapidly descending into the flooded streams during every rain storm or thaw; and the streams were choked up with the materials carried from the storm-swept barren slopes. Splendid groves have thus been replaced by worthless farms from which even the mortgage cannot be raised. That this is not the creation of idle fancy is known to every one who has lived and observed in the eastern and southern portions of the state during the past twenty-five or thirty years. Abundant examples may be found along the Iowa river above Iowa City, and along every larger stream in the state.

In the meantime the settlers on the prairies realized to some extent that that which had been regarded as an obstacle was in reality a blessing. They missed the shade, the companionship and the protection of the trees which in their eastern homes they had regarded as obstructions. They planted groves for windbreaks, gave some attention to improved methods of tree culture and persuaded the legislature to enact laws encouraging the planting of trees. Everywhere in the prairie portions of the state more or less interest was manifested in the cultivation of forest trees. Many of the first efforts were wholly or in part unsuccessful. It soon became apparent that many of the methods of tree culture practiced in the east failed in

Iowa, and evil prophets declared that these failures were sufficient evidence that the causes which left the original prairies treeless would operate to keep them so notwithstanding the efforts of man to the contrary. Experience has since shown that trees may be successfully grown in any part of our state, but this is sometimes accomplished at such great comparative cost, and the results are sometimes so uncertain, that there are still those who think that tree planting, excepting on a very small scale, cannot be successfully undertaken in this state.

This raises again a question of profound interest to our people. Not only the material interests of the state, but in a large measure the health and happiness of its citizens, are at stake. If it is true that it is not worth while to try to grow trees in Iowa, then some of our citizens are wasting money, time and energy in the attempt, and the effort to build up pleasant, well-protected, healthful homes in a large part of the state must result in disappointment and disaster. If, on the other hand, trees may be successfully grown in our state,—if it can be shown that the obstacles to success in that direction can be overcome,—then, as citizens of the state, we are not doing our duty if we fail to attempt to awaken public conscience to a realization of the fact that we are guilty of a crime against posterity when we permit the splendid opportunities which are now within easy reach to slip by unnoticed and unused. Forests are not made in a day. Whatsoever we do in this direction is largely for posterity's sake, though we ourselves may reap some of the fruits of our labor.

There is, however, no warrant, either in the results of scientific research or in the practical experience of tree-growers, for the statement that trees cannot be successfully grown in this state. We are on the border-line between the comparatively moist east and the dry west. The conditions favorable to the growth of forests are not at their best here, it is true,—neither are they at their worst. The treeless condition of a large part of the state was no doubt due to a combination of causes.*

*See writer's discussion of this subject in Proc. Iowa Acad. Sci., Vol. VII, pp. 47 *et seq.*

Not one of these causes was of itself sufficient to produce our treeles prairies, and not one of them is entirely proof against the influence of man. Prairie fires have long since ceased to be a serious menace: the evil effects of lack of moisture are in part overcome by modern methods of surface cultivation. and will grow less as the forest area is increased; extremes of temperature lose much of their terror if mulching is practiced: the force of winds is broken by groves and tree-borders, and by judicious attention to topography; and soils may be improved by cultivation and by the use of fertilizers. If the tree-grower gives heed to all this, and if he takes further precautions by selecting hardy native or acclimated stock. preferably very small or grown from the seed in order that the roots may not be disturbed, and protects his trees against cattle and other domestic and native animals, he will have success. However, all this requires intelligent care, time and patience, and naturally suggests the question: "Does it pay?" It is safe to say that as a money making investment which will bring early returns it is not a success.*

The writer believes that as an investment for one's children it does pay, but few people think far enough in advance, or can afford to let a part of their capital lie idle during their own lives for that purpose. There are, however, immediate returns which the tree planter himself lives to enjoy. Trees add to the beauty of our surroundings. Nothing can equal the charm of those native groves which formed, and in limited areas still form, natural parks, and nothing has so overcome the appalling monotony of our prairies as the groves set out by men yet living.

But other immediate benefits result from growing trees whether in artificial or native groves. They act as windbreaks against both the cold blasts of winter and the leveling storms of summer, and thousands of homes in Iowa are made habitable only by their presence. They serve to equalize temperature, as groves and their imme-

*For illustration see paper by Elmer Reeves, read before the Iowa Park and Forestry association in December, 1901, and published in its first proceedings.

diate vicinities are uniformly cooler in summer and warmer in winter.*

They conserve the moisture of the soil. The fine leaf-mould which naturally accumulates in groves forms a sponge which greedily takes up the water which falls as rain or snow, and this is later given off by springs. Rapid evaporation is prevented, but instead the trees pump up water from the more thoroughly saturated soil and throw it off gradually into the air through the leaves, thus supplying moisture for the local summer showers which are the salvation of our crops. Forests cannot be classed with the general causes which determine the precipitation of abundant rains in the spring and fall, but their effect upon local showers is consistent with scientific observations upon the physiological activity of trees and green plants in general, and cannot be successfully questioned. It is absurd to state that growing crops replace groves in all the good work accomplished in the direction of conserving moisture. Crops are left upon the ground during only a portion of the season. Moreover, they appear so late in the season that they cannot aid in the retention of that moisture which results from melting snow, or which is precipitated in the early rains. Crops cannot therefore, conserve moisture to the same extent, though in kind their work is like that of all green plants.

Forests prevent erosion. In the roughest timbered country even the lightest leaf-mould on the steepest slopes is practically undisturbed by torrents of rain, and the waters which are drained from such surfaces are clear, since they carry but little eroded material. As quickly as the forest is cleared the spongy surface soil is washed away, and even the harder sub-soils are washed out. The result is noticeable along all of our larger streams which have been deprived in large part of their bordering native groves. The material which is being washed from the exposed slopes is choking up our streams, and sandbars and mudbars are rapidly increasing.

*For results and data of observations on effect of forests on temperature and moisture, see Forest Influences, Bulletin No. 7, Forestry Div., U S. Dept. of Agr., 1893; and 11th Ann. Rep. Agr. Ex. Sta., Univ. of Wis., pp. 292-326, 1895.

The beneficent influence of groves upon winds, temperature, moisture and erosion are felt not alone by him who plants or protects trees—they are shared by the entire community. In view of this fact, and in view of the fact that as an immediate money-making investment tree-planting does not pay, some encouragement ought to be given by the state to those who use their lands and money for the preservation and propagation of trees. Laws, of course, will not make trees grow, neither will they teach men how to give intelligent care to them. But laws can be so framed that men will be encouraged to undertake the work of increasing our forest areas without being fined by a tax for efforts which are bringing benefits to the entire community without corresponding adequate material returns to those who are making them.

Our state is at present wholly without forestry laws. The old law, which has been on the statute books for about a quarter of a century, was omitted by the last code commission, one of the commissioners objecting to it because of the frauds which were practiced under it. Amendment and not repeal should have been the remedy. Experience proved that this old law was weak in many respects. No restrictions were placed on the kinds of trees to be planted, with the result that perhaps 90 per cent of the trees planted in the prairie sections of the state were undesirable cottonwoods, box elders, soft maples and willows. The law did not sufficiently define the care that should be taken of the trees, and the result was a widespread neglect of the groves. It provided an exemption of $100 per acre for ten years for forest trees, and $50 per acre for five years for fruit trees. No encouragement was offered for the protection of the forest trees after the ten years had passed, with the result that in many places the old groves were cut away and new ones were set out. The law should have provided not only for the planting of new groves, but for the care and protection of old artificial and native groves. The exemption was sufficiently large to tempt some men owning unim-

proved prairie lands to perpetrate fraud. This could have been avoided by proper restrictions. Notwithstanding its defects, however, the law was a blessing to the prairie sections of the state. Thousands of acres of artificial groves which owe their existence to this law, have completely changed the prairie landscapes of Iowa, and the results amply justified the existence of the law notwithstanding the occasional frauds. It is, however, high time that the comparatively worthless trees of most of these groves be replaced by trees whose ultimate value is much greater, and that steps be also taken to restore at least in part the original forests of the state. It cannot be expected that very much of the land whose value reaches $100 per acre will be used for forestry purposes, but there is much land, probably 15 per cent of the total area, in this state which is worthless for agricultural purposes but will grow trees, and this should be used for that purpose, It is not, however, to be expected, for the reasons herein enumerated, that much of this poorer land will be so used unless some substantial recognition is given to the owners, —such as release from the burdens of taxation.

The Iowa Park and Forestry Association has recently approved a bill which will be submitted to the Twenty-ninth General Assembly which seems to meet the objections made to the old law, and it is here presented for approval. It is believed that this is at least a step in the right direction, and should be encouraged.

A BILL

For an act to encourage the planting of forest and fruit trees in the state of Iowa.

SECTION 1. *Be it enacted by the Twenty-ninth General Assembly of the State of Iowa:*

That on any tract of land in the state of Iowa the owner or owners may select a permanent forest reservation not less than two acres in continuous area, or a fruit tree reservation not less than one nor more than five acres in area, or both, and that upon compliance with the provisions of this act such owner or owners shall be entitled to the benefits hereinafter set forth.

SEC. 2. A forest reservation shall contain not less than two hundred growing forest trees on each acre. If the area selected is an original forest containing the required number of growing forest trees, it shall be accepted

as a forest reservation under the provisions of this act. If the area selected is an original forest containing less than two hundred forest trees to the acre, or if it is an artificial grove the owner or owners thereof shall have planted, cultivated and otherwise properly cared for the number of forest trees necessary to bring the total number of growing trees to not less than two hundred on each acre, during a period of not less than two years, before it can be accepted as a forest reservation within the meaning of this act.

SEC. 3. Not more than one-fifth of the total number of trees in any forest reservation may be removed in any one year, excepting in cases where the trees die naturally.

SEC. 4. The ash, black cherry, black walnut, butternut, catalpa, coffee tree, the elms, hackberry, the hickories, honey locust, locust, mulberry, the oaks, sugar maple, European larch and other coniferous trees, and all other forest trees introduced into the state for experimental purposes, shall be considered forest trees within the meaning of this act. In forest reservations which are artificial groves, the willows, box elder, soft maple, cottonwood and other poplars, shall be included among forest trees for the purpose of this act when they are used as protecting borders not exceeding two rows in width around a forest reservation, or when they are used as nurse trees for forest trees in such forest reservation, the number of such nurse trees not to exceed one hundred on each acre.

SEC. 5. The trees of a forest reservation shall be in groves not less than four rods wide.

SEC. 6. A fruit tree reservation shall contain not less than ninety fruit trees on each acre, growing under proper care, and may be claimed as such for a period of five years after planting.

SEC. 7. The cultivated varieties of apples, crabs, plums, cherries, peaches and pears shall be considered fruit trees within the meaning of this act

SEC. 8. Whenever any tree or trees on a fruit tree or forest reservation shall be removed or die, the owner or owners of such reservation shall, within one year, plant and care for other fruit or forest trees, in order that the number of such trees may not fall below that required by this act.

SEC. 9. Cattle, horses, mules, sheep, goats and hogs shall not be permitted to pasture upon a fruit tree or forest reservation.

SEC. 10. Forest reservations fulfilling the conditions of this act shall be assessed on a taxable valuation of one dollar per acre.

Fruit tree reservations shall be assessed on a taxable valuation of one dollar per acre for a period of five years from the time of planting.

In all other cases where trees are planted upon any tract of land, without regard to area, for shade or ornamental purposes, or for windbreaks, the assessor shall not increase the valuation of such property because of such improvements.

SEC. 11. If the owner or owners of a fruit or forest reservation violate any provision of this act within the two years preceding the making of an assessment, the assessor shall not list any tract belonging to such owner or owners as such reservation for the ensuing two years.

SEC 12. It shall be the duty of the assessor to secure the facts relative to fruit and forest reservations by taking the sworn statement, or affirmation, of the owner or owners making application under this act.

Sec. 13. It shall be the duty of the county auditor in every county to keep a record of all forest and fruit tree reservations within his county.

Sec. 14. The secretary of the Iowa State Horticultural Society shall be state forestry commissioner, without salary. It shall be his duty to promote the objects of this act, and he shall have power to appoint deputies without salary for each county, or group of counties, who shall assist him, and who shall make an annual report to him of forestry matters and of the operations of this act, within their respective territories.

(NOTE.—This bill was subsequently passed by the House, and was favorably reported by the Senate committee on horticulture, but did not receive a constitutional majority in the Senate.)

ANALYSES OF CERTAIN CLAYS USED FOR MAKING PAVING BRICK FOR CEDAR RAPIDS.

BY C. O. BATES.

The following analyses were made several years ago for Mr. E. P. Boynton, the city engineer of Cedar Rapids. The clays were taken from four companies in Des Moines; each having their plant in a different part of that city.

	Silica SiO_2.	Alumina Al_2O_3.	Iron Oxide Fe_2O_3.	Lime CaO.	Magnesia MgO.	Total alkalies Na_2O and K_2O.	Hydroscopic moisture H_2O.	Ignition loss H_2O, CO_2, S, etc.	
C—0	55.25	25.60	5.52	1.75	1.49	1.79	3.27	5.07	99.74
C—1	53.08	24.93	9.00	.94	1.84	1.19	3.29	5.73	100.00
C—2	61.18	21.69	5.88	.51	1.92	1.96	1.27	5.01	99.42
C—3	68.60	18.93	6.[illegible]2	.25	.68	.74	1.80	2.80	99.92
C—4	65.62	16.83	8.64	.42	2.00	1.66	.60	4.10	99.87
C—5	51.35	27.38	6.60	1.45	2.62	2.34	2.81	5.42	99.97
C—6	58.42	20.04	7.80	1.68	2.67	1.56	2.39	5.40	99.96
I—1	55.98	25.65	5.88	.74	1.84	1.95	3.72	3.73	99.53
I—2	81.79	10.25	3.24	.52	.57	1.75	.58	1.27	99.97
I—3	68.50	88.45	5.28	1.19	1.42	1.27	.88	2.82	99.81
I—4	52.88	24.27	11.28	.52	2.03	1.92	3.46	3.28	99.64
I—5	66.73	20.28	3.24	.70	.90	1.46	1.70	4.92	99.93
I—6	64.60	20.25	6.72	1.20	1.02	1.33	1.14	3.74	100.00
I—6½	64.82	21.00	5.76	.42	2.48	2.11	.33	3.10	100.02
I—7	57.25	22.50	7.92	.90	2.28	1.41	3.88	3.62	99.76
I—8	53.05	25.92	8.76	1.00	2.73	1.29	2.70	4.40	99.85
D—1	70.29	15.18	7.32	.80	1.72	1.49	1.02	2.18	100.00
D—2	59.18	21.63	9.00	1.06	1.85	1.52	1.95	3.80	99.99
D—3	64.60	19.20	7.68	1.02	1.37	1.25	.92	3.95	100.01
D—4	64.41	20.43	5.88	.34	1.71	1.90	1.27	3.93	99.77
D—5	63.23	24.52	5.28	.32	.99	1.16	1.75	2.55	99.80
D—6	76.01	11.94	5.40	1.57	1.04	1.80	.65	1.41	99.82
D—7	67.76	14.46	8.52	1.16	2.36	1.24	.67	3.53	99.70
D—8	55.56	21.33	10.56	1.59	2.94	2.38	.97	4.65	99.98
F—1	70.23	15.68	7.44	.47	1.50	1.26	1.50	1.82	99.90
F—2	69.89	17.68	5.64	1.05	1.68	1.15	.85	1.97	99.91
F—3	58.92	21.45	8.40	.98	2.90	2.49	.57	4.13	99.84
F—4	50.38	27.25	11.54	.96	2.93	1.65	1.45	3.62	99.78
F—5	62.70	21.32	5.88	.16	1.77	1.15	2.12	4.90	100.09
F—6	64.31	17.64	7.68	1.12	2.40	1.15	.42	5.47	99.98
F—7	64.03	20.73	6.72	.36	2.57	1.30	.42	3.50	99.60

(1.) CAPITAL CITY BRICK AND TILE WORKS. This plant is located south of the city. Seven samples were taken which were representative of the principal layers. The following is a description of each, beginning at the top:

		Thickness in feet.
C—0.	Clear, medium light drab with slight seams of rust, mastic, very slightly gritty	7
C—1.	Shale, mottled and streaked maroon to sea green, greenish and purplish brown, rust in seams	4½
C—2.	Shale, medium dark bluish drab. clean	7
C—3.	Bastard fire clay, mottled purplish blue, dark gray, slight rust in seams	4
C—4.	Shale, soapy, but containing some grit, clear grayish drab	15
C—5.	Shale, very dark greenish gray with slight seams of rust	1½
C—6.	Shale, clear blue sandy	10

(2.) IOWA BRICK COMPANY. The works of this company are located in the northwestern part of the city on the opposite side of the river from the Flint Brick Company.

Nine samples were taken from this pit. The following is a description of each of the different strata, beginning at the top:

		Thickness in Feet.
I—1.	Shale, variegated, reddish brown, mahogany reds, yellowish, bluish drab, dark gray, almost black; the colors mottled parallel to bed	6
I—2.	Sandy, light yellowish white, solid color	6
I—3.	Slightly sandy at top to clear shale below, pale blue streaked with chocolate brown	5
I—4.	Shale, clear chocolate brown	4
I—5.	Shale, granular, dark solid drab with reddish purple nodules	3
I—6.	Shale, bluish drab	6
I—6½	Same as No. 6. exposed at western end of cut, weathered	?
I—7.	Shale, streaks of brownish drab and greenish, to chocolate brown. Stratification well defined	6
I—8.	Clear dark drab, with orange green tinge	2

(3.) THE DES MOINES BRICK MANUFACTURING COMPANY is located in West Des Moines, between the tracks of the C., R. I. & P. R'y and the Des Moines & Northern R'y.

The following is the description of each of the eight strata in this pit, beginning with the top:

		Thickness in Feet.
D—1.	Clay, variegated	5
D—2.	Shale, streaked in color	4
D—3.	Shale, solid chocolate brown color, clear definition.	5
D—4.	Shale, solid color, clear to poor definition	5
D—5.	Shale, variegated, clear to poor definition	3
D—6.	Shale, sandy, solid color	10
D—7.	Shale, sandy, clear definition, solid color, granulated texture, pulverizes in the hand: thickness.	5
D—8.	Shale, gray, clear definition. This clay forms 38 to 40 per cent of the bank and runs to underlying coal	23

(4.) THE FLINT BRICK COMPANY is located in Oak Park upon the Des Moines river. Seven samples were analyzed from this pit. A complete description of the strata was not obtainable at the time the samples were taken.

THE SANITARY ANALYSES OF SOME IOWA DEEP WELL WATERS.

BY J. B. WEEMS.

In the investigation of deep well waters the interest in many cases has been limited to the mineral substances, and little attention given to the sanitary analysis. This is a natural result when it is realized that these waters con tain large amounts of solids and the possibility of contamination by sewage or other products is very slight indeed. In connection with the work of the Department of Agricultural Chemistry of the Agricultural College, analyses of a number of samples of water from the deep wells of the state have been made and the results brought together in hope that they may be of interest. The methods used do not require any explanation as they are those which have been generally used for analyzing water. The oxygen

absorption may, however, be given some attention, as this part of the analytical work has not reached a satisfactory position. The method of oxygen absorption used is what may be called the "English method" and was first proposed by the Association of Public Analysts of England and is outlined in connection with another investigation published recently.*

In the analyses of the deep well waters the amount of free ammonia at once attracts attention. This is not a new observation but has been recognized for some time as quoted by Mason.†

THE SANITARY ANALYSIS OF WATERS FROM SOME OF THE DEEP WELLS OF IOWA.

LOCATION.	Free ammonia.	Albuminoid ammonia.	Chlorine.	Solids on evaporation.	Nitrogen as nitrites.	Nitrogen as nitrates.	Oxygen consumed, 15 minutes.	Oxygen consumed, 4 hours.	Depth of well.
Amana	1.005	T	18.42	1088.57	0	0	.24	.264	1,640
Ames	.18	.024	51.00	1226.00	.4	T	.32	.48	2,215
Boone	1.4	.015	152.90	2047.14	0	0	.74	.74	3,010
Cedar Rapids	.86	.016	.43	592.90	.3	.16	.80	1.00	1,450
Centerville	.978	.02	388.60	4132.14	4.8	0	1.68	2.48	1,540
Davenport	1.10	.005	273.00	1192.86	0	0	.96	.99	
Dubuque	.02	T	T	288.57	0	0	.10	.45	
Holstein	.62	.036	21.70	1527.00	T	T			
Homestead	.95	.00	33.14	1088.57	0	0	.43	.64	2,224
Iowa Falls	.79	.068	12.00	446.00	0	0	6.10	9.10	
Keokuk (Pickle Co.)	1.22	.03	633.00	3637.14	.42	0	1.38	2.42	710
Keokuk (Poultry Co.)	1.50	.015	674.00	3727.14	0	0	.43	.75	700
Manchester No. 1	.05	.012	9.00	304.00	0	.9	......	....	(1)1,870
Manchester No. 2	.03	.06	80.00	490.00	0	.25	......	....	(2)1,870
McGregor well No. 1	1.25	.0175	967.90	2795.00	0	0	.68	2.49	1,006
McGregor well No. 2	.02	.01	36.00	372.86	0	0	.29	.50	502
Monticello	.013	.015	5.9	371.43	0	0	.46	.98	1,198
Newton	2.27	.186	183.00	4716.00	0	0	2.56	26.88	1,400
Sabula	.08	.006	T	295.71	0	0	.16	.62	973
Sioux City	1.25	.015	84.1	1617.14	0	0	.06	1.85	
Waverly	.49	.01	6.00	544.00	0	0	.2	1.4	
Webster City	.15	T	10.3	1051.43	0	0	.3	.9	1,250
West Bend	1.45	.01	5.71	681.43	0	0	.99	1.43	381

(1) 980 feet of casing.
(2) 1,300 feet of casing.

"The 'free ammonia' in artesian wells is often excessive, under circumstances that make animal contamination an impossibility, and even rain water, freshly collected after periods of long drought, will often exhibit properties calculated to mislead the analyst."

*Weems & Brown. Influence of Chlorine as Chlorides in the Determination of Oxygen Consumed in the Analysis of Water. Proc. Iowa Acad. of Sciences, 8, p. 87.

†Water Supply, p. 302.

The excessive amount of free ammonia in deep well water is accounted for by Fox* as follows.

1. To entrance of rain water into well.

2. To the beneficial transformation of harmful organic matter into the harmless ammonia, through the agency of sand, clay, and other substances, which act on the water in a manner similar to the action on it of a good filter.

3. To some salt of ammonia existing in the strata through which the water rises; or,

4. To the decomposition of nitrates in the pipes of the well. Mr. H. Slater suggests that the agent concerned in this reduction may, in the case of the deep well waters, be the sulphide of iron which is found in the clay.

Ammonia may be converted into nitrates and nitrites by a process of oxidation, or be obtained from these salts by one of reduction. We conclude, then, that the presence of free ammonia in such comparatively large quantities in these deep well waters is due to the reduction of nitrates and nitrites by sulphide of iron, or some kinds of organic matter, or some other agent, such oxidized nitrogen salts having been produced in past ages by the oxidation of organic matter."

The State board of health standard limits the free ammonia to .08 parts per million while the Michigan Standard is .05 parts per million and if we attempt to apply these standards we find that of the wells investigated only Dubuque, McGregor No. 2, and the two Manchester will meet the requirement of the two standards and Sabula will meet, in addition to those named, the state limit for free ammonia.

The amount of albuminoid ammonia in the waters will however meet the most exacting requirements. The only exception is that of the Newton sample and this should be investigated again before any definite conclusions are drawn regarding the amount of albuminoid ammonia. If we except this sample it is seen that the results vary from .068 parts per million to a trace.

*Sanitary examinations of water, air and food. Second Ed. p. 92.

Wanklyn classifies waters according to the amount of albuminoid ammonia present as follows:

.05 parts per million. Great purity.
.10 parts per million. Organically safe.
Greater than 10 parts per million. More or less impure.

The small amount of albuminoid ammonia present in the deep well waters places them in the class which is regarded by Wanklyn as characterized as being of great purity. This fact that as far as organic contamination is concerned, the deep well waters are pure waters and this consideration aids in the interpretation of the results obtained for free ammonia as Wankyln considers the presence ot free ammonia as follows:

"If a water yield .000 parts of albuminoid ammonia per million, it may be passed as organically pure, despite of much free ammonia and chlorides; and if indeed the amount of albuminoid ammonia amount to .02, or to less than .05 parts per million, the water belongs to the class of very pure water."

The State Standard is .15 parts of albuminoid ammonia per million which is larger than the amount of albuminoid ammonia in all of the samples except that of Newton. The Michigan standard being the same as that of Iowa.

The presence of chlorine in the form of chlorides naturally does not indicate contamination and the standard of the state board of health of 8 parts per million is of no value for the deep well waters, where the sodium chloride is very high in many samples of water. In the sample of water from McGregor well No. 1 it is seen that chlorine is present to the extent of 967.9 parts per million, and this substance varies from this large amount to a trace in the water from the Dubuque well. When it is considered that the deep well waters contain large quantities of dissolved salts they naturally are associated with the water from mineral springs,* as for example the spring Ems contains 487 parts, Spa 35.5 parts, Carlsbad 630, and Wiesbaden 4687 parts of chlorine per million.

*Smith 1888 p. 830

The standards as given by Mason† for chlorine are as follows:

Rain	8.22
Upland surface	11.3
Deep well	51.1
Spring	24.9

Wanklyn considers 140 as possibly suspicious.
Frankland considers the permissible limit as 50.
Leed's standard for American rivers, 3 to 10.
Ordinary sewage, about 110 to 160.
Human urine (average of 24 samples), 5872.

It will be noticed that the standard for deep wells, 51.1 parts per million cannot be applied to the deep well waters of this section, and any standard is of little value as far as it relates to the chlorine that is present in the water, however useful the standard for this substance may be for shallow wells.

The solids on evaporation in the examination of shallow wells is a determination of great value, although the loss on ignition has lost much of its supposed value. In connection with the examination of deep well water, however, its chief value may be said to serve simply as a guide to the total substances present in the water, the nature of which can only be determined by a mineral analysis. The various standards which have been proposed for the solids on evaporation cannot be applied to the deep well water or to the mineral waters. For example the standards which have been selected by Mason,* are as follows.

Rain water	29.5
Upland surface	96.7
Deep well	432.8
Spring	282.0
To be condemned	1000.
American rivers	150. to 200.
Wanklyn regards as permissible	575.

Many of the deep well waters will come within the limits for solids as a few of the solids contained less than 600 parts per million. On the other hand many of the results show that the solids are in excess of 1,000 parts per

†Water Supply. p. 374.
*Water Supply. p. 368.

The beneficent influence of groves upon winds, temperature, moisture and erosion are felt not alone by him who plants or protects trees—they are shared by the entire community. In view of this fact, and in view of the fact that as an immediate money-making investment tree-planting does not pay, some encouragement ought to be given by the state to those who use their lands and money for the preservation and propagation of trees. Laws, of course, will not make trees grow, neither will they teach men how to give intelligent care to them. But laws can be so framed that men will be encouraged to undertake the work of increasing our forest areas without being fined by a tax for efforts which are bringing benefits to the entire community without corresponding adequate material returns to those who are making them.

Our state is at present wholly without forestry laws. The old law, which has been on the statute books for about a quarter of a century, was omitted by the last code commission, one of the commissioners objecting to it because of the frauds which were practiced under it. Amendment and not repeal should have been the remedy. Experience proved that this old law was weak in many respects. No restrictions were placed on the kinds of trees to be planted, with the result that perhaps 90 per cent of the trees planted in the prairie sections of the state were undesirable cottonwoods, box elders, soft maples and willows. The law did not sufficiently define the care that should be taken of the trees, and the result was a widespread neglect of the groves. It provided an exemption of $100 per acre for ten years for forest trees, and $50 per acre for five years for fruit trees. No encouragement was offered for the protection of the forest trees after the ten years had passed, with the result that in many places the old groves were cut away and new ones were set out. The law should have provided not only for the planting of new groves, but for the care and protection of old artificial and native groves. The exemption was sufficiently large to tempt some men owning unim-

been previously stated is a process which is in a very unsatisfactory state at present. In England we find the modification of the Miller-Tidy method used at present. This method as modified by the Society of Public Analysts we have designated as the English process. The Kubel process and its modifications we find used in this country and in Europe under its proper name and with slight changes under other terms, such as "boiling method." The time of boiling may vary from five to thirty minutes while the time recommended by the American Association is ten minutes. The objection which has been made against the Kubel method is that at the boiling temperature the permanganate acts upon the chlorides present in the water and for this reason many prefer the English method where the temperature of the reaction is 80 degrees Fahrenheit. The object in making the tests at fifteen minutes and four hours is that the fifteen minute test indicates the amount of organic matter readily putrefying and rapidly decomposing permanganate with acid. Angus Smith classed this as organic matter readily decomposed and probably ready to become putrid. The fifteen minute test also includes in the result the action of any nitrites, ferrous iron or hydrogen sulphide which may be present.

The object of the four hour test is supposed to indicate the organic matter capable of putrefying although slow to be decomposed. The total result includes the readily decomposed matter in the fifteen minute test which must be subtracted from the total if the amount of oxygen necessary for the organic matter which is slow to be decomposed is desired. The three minute test is also of value in many determinations as well as the association method. The association method giving results which indicate the total organic matter present is much better than the four hour test in many investigations, although care must be taken regarding the presence of large quantities of chlorine.

Tidy's classification of waters based upon the oxygen absorption is as follows :

Class I. Waters of Great Organic Purity. All waters in which the oxygen absorbed does not exceed .5 parts per million

Class II. Waters of Medium Purity. Waters in which the oxygen absorbed ranges from .5 to 1.5 parts per million.

Class III. Waters of Doubtful Purity. Waters in which the oxygen absorbed ranges from 1.5 to 2.2 parts per million.

Class IV. Impure Waters. Waters in which the oxygen absorbed exceeds 2.2 parts per million.

The Michigan standard is that water should not require over 2.2 parts of oxygen per million.

It is of interest to note that some of the deep well waters come within the first class of waters according to Tidy's classification and the larger number within the Michigan standard. The application of any standard to the sanitary analysis of the deep well waters is unsatisfactory and misleading in many ways. The most important results, that of albuminoid ammonia and nitrogen as nitrites and nitrates show conclusively that the waters are not contaminated in any manner. The oxygen absorption is valuable in many respects, but the other results vary to such a degree that no standard can be selected which could be applied to the deep well waters as can be done for the waters from shallow wells.

THE CHEMICAL COMPOSITION OF SEWAGE OF THE IOWA STATE COLLEGE SEWAGE PLANT.

BY J. B. WEEMS, J. C. BROWN AND E. C. MYERS.

The sewage plant of the college was constructed in 1898 from the designs and under the supervision of Prof. A. Marston, the college engineer. The plans and a short description of the work of the plant have been recently published* and only the chemical investigations will be considered in this paper.

*The Iowa State College Sewage Disposal Plant and Investigations. Marston, Weems and Pammel. Proceedings Iowa Engineering Society, 1900.

The chemical work began in 1898 and continued from the seventh to twenty-sixth of October of that year. Commencing in 1899 samples were taken from January 10 to October 1, 1901. During this period samples of the manhole or raw sewage, tank and effluent were taken weekly and analyzed as soon as possible on reaching the laboratory. After October 1, 1901, samples were taken each month only.

Date.	Ammonia.		Chlorine.	Solids.			Nitrogen as		Oxygen consumed.		Origin.
	Free.	Albuminoid.		On evaporation.	At 180°.	On ignition.	Nitrites.	Nitrates.	Fifteen min.	Four hours.	
1898											
Oct. 7	25.1	4.3	......	1941	1857	......	0	0	......	....	Manhole.
Oct. 7	26.4	7.5	....	1804	1696	.....	......	T	....	......	Tank.
Oct. 7	2.9	.7	....	1692	1629		....	10.	....	....	Effluent.
Oct. 13	43.	30.2	110.	3302	3000	2055	0	T	......	......	Manhole.
Oct. 13	16.0	3.95	80.	2616	2330	2278	0	T	....	....	Tank.
Oct. 13	.13	.32	80.5	2407	2150	2036	.3	10.	....	....	Effluent.
Oct. 21	26.8	5.95	99.	2438	2310	1994	.1	.15	....	....	Manhole.
Oct. 21	26.05	10.45	77.	1086	928	822	T	.15	....	....	Tank.
Oct. 21	.1	.24	92.	2596	2402	2384	.5	.4	....	....	Effluent.
Oct. 26	49.3	33.5	99.	3402	3042	2440	0	T	....	....	Manhole.
Oct. 26	27.8	7.35	77.	2660	2476	2296	0	T	....	.....	Tank.
Oct. 26	.46	1.69	61.	2418	2244	2174	.6	.75	......	....	Effluent.
1899.											
May 10	36.7	22.8	88	1182	1147	1040	0	T	81.6	129.6	Manhole.
May 10	12.3	14.6	107	1628	1510	1409	0	T	78.4	177.6	Tank.
May 10	.20	22	112	1709	1675	1554	.16	10	6.4	44.8	Effluent.
May 17	31.7	20.0	80	1232	1179	1001	.1	.4	16.	99.2	Manhole.
May 17	10.7	7.4	113	1590	1522	1215	0	T	48.	153.6	Tank.
May 17	.24	.7	96	1670	1658	1528	.3	6.0	[illegible].8	24.0	Effluent.
May 24	46.6	15.7	83	1223	983	789	.6	1.6	64.	252.8	Manhole.
May 24	13.1	12.2	119	1612	1526	1217	.4	T	142.4	344.0	Tank.
May 24	.52	.36	168	1361	1351	1162	.16	8.0	9.6	100.8	Effluent.
May 31	27.4	6.7	62	1384	1330	1141	0	0	88.	129.6	Manhole.
May 31	14.3	14.7	125	1927	1857	1425	.16	0	152.0	425.6	Tank.
May 31	2.9	0.25	111	1597	1461	1272	T	4.0	3.2	24.0	Effluent.
June 7	56.6	42.7	91	1676	1673	1392	0	0	85.6	22.2	Manhole.
June 7	17.3	30.1	150	2008	1941	1555	0	0	121.6	352.	Tank.
June 7	8.16	6.9	140	1740	1735	1468	0	0	33.6	116.8	Effluent.
June 14	55.6	20.3	94	1569	1505	1305	0	0	56.	204.8	Manhole.
June 14	16.8	14.1	70	1498	1420	1265	0	0	38.4	219.2	Tank.
June 14	.72	5.36	62	1489	1460	1307	.2	6.0	17.6	43.2	Effluent.
June 21	24.8	14.5	39	1275	1212	1096	.6	4.0	8.	97.6	Manhole.
June 21	9.1	4.0	40	1230	1175	1031	.8	1.0	8.	129.6	Tank.
Effluent	not br	ought	in.								
June 28	2.02	2.58	43	1175	1120	981	.8	2.0	6.4	48.	Manhole.
June 28	5.62	16.58	112	1584	1395	1096	0	T	102.4	219.2	Tank.
June 28	.13	.43	86	1340	1322	1146	0	2.0	4.8	36.8	Effluent.
July 6	15.8	9.8	51	1095	998	914	.96	2.0	148.8	379.2	Manhole.
July 6	3.0	16.8	144	1520	1332	1007	.8	1.0	233.6	860.8	Tank.
July 6	2.2	5.0	53	1223	1178	931	.16	6.0	41.6	336.	Effluent.
July 12	16.0	78.5	63	1239	1117	899	.1	.4	123.2	304.0	Manhole.
July 12	2	38.0	168	1800	1356	962	T	0	36.8	387.2	Tank.
July 12	1.4	1.8	......	1[illegible]01	1474	1052	.16	26.	14.4	237.2	Effluent.
July 19	10.4	29.6	412	1269	1189	970	.3	.8	22.4	94.4	Manhole.
July 19	5.8	18.2	141	1682	1383	972	0	0	177.6	371.2	Tank.
July 19	3.4	6.0	120	1433	1400	1188	.08	6.0	1.6	48.0	Effluent.
July 26	10.7	15.8	24	865	793	475	.8	2.0	54.4	14[illegible].8	Manhole.
July 26	9.2	17.3	22[illegible]	1534	1444	1090	0	0	81.6	232.0	Tank.
July 26	.32	1.54	110	1527	1448	1190	.2	10.	10.4	40.	Effluent.
Aug. 2	47.9	28.2	50	1100	995	815	.6	2.0	75.2	209.6	Manhole.
Aug. 2	12.8	13.8	32	808	780	496	0	0	43.2	150.4	Tank.

DATE.		AMMONIA.		Chlorine.	SOLIDS.			NITROGEN AS		OXYGEN CONSUMED.		ORIGIN.
		Free.	Albuminoid.		On evaporation.	At 180°.	On ignition.	Nitrites.	Nitrates.	Fifteen min.	Four hours.	
Aug.	2	.16	1.24	39	983	921	786	T	6.0	4.8	32.	Effluent.
Aug.	9	57.7	48.4	88	1454	1132	864	.8	.4	126.4	198.4	Manhole.
Aug.	9	17.9	16.9	35	971	870	705	.04	T	33.6	140.8	Tank.
Aug.	9	.34	1.74	62	1181	1022	903	.16	10.	8.0	12.8	Effluent.
Aug.	17	49.7	30 6	107	879	776	604	0	0	105.6	206.4	Manhole.
Aug.	17	18.4	19.9	49	1086	951	794	0	0	83.2	192.0	Tank.
Aug.	17	.3	.66	100	1383	1302	1221	.4	10.0	9.6	62.4	Effluent.
Aug.	25	....	86.0	76	......	1425	1345	T	0	....	......	Manhole.
Aug.	25	......	72.	122	1796	1664	1456	T	0	....	....	Tank.
Aug.	25	....	14.2	115	1618	1568	1441	.12	6.0	....	....	Effluent.
Aug.	29	27.7	31.2	92	1730	1532	1406	0	0	97.6	238.4	Manhole.
Aug.	29	32.3	21.3	23	1917	1608	1500	0	0	96.0	248.	Tank.
Aug.	29	.7	.72	78	1651	1595	1540	.24	6.0	11.2	46.4	Effluent.
Sept.	5	3.4	3.8	79	1418	1369	1140	0	0	14.4	60.8	Manhole.
Sept.	5	14.5	13.1	89	1524	1381	122	.4	0	27.2	140.8	Tank.
Sept.	5	1.08	1.58	96	1610	1571	1350	.4	5.0	3.2	48	Effluent.
Sept.	12	48.5	37.1	175	1624	1535	1191	0	0	73.6	193.6	Manhole.
Sept.	12	28.8	38.6	85	1692	1603	1306	0	0	83.2	220.8	Tank.
Sept.	12	.48	.66	94	1515	1415	1195	.8	6.0	9.6	38.4	Effluent.
Sept.	19	56.5	22.7	67	1141	1024	950	1.0	.2	136.0	307 2	Manhole.
Sept.	19	36.5	20.9	67	1260	1165	1026	1.0	T	78.4	172.8	Tank.
Sept.	19	.9	.62	104	1730	1635	1606	.12	8.0	9.6	56.0	Effluent.
Sept.	25	65.9	29.2	281	1318	1230	830	0	0	164.8	438.4	Manhole.
Sept.	25	27.4	26.1	67	1063	812	681	0	0	124.8	304.0	Tank.
Sept.	25	.7	1 34	45	903	843	611	.6	7.0	9.6	59.2	Effluent.
Oct.	2	84.3	34.8	142	1693	1620	1221	0	T	118.4	422.4	Manhole.
Oct.	3	52.5	19.5	147	1814	1547	1295	0	0	120.0	326.4	Tank.
Oct.	3	1.02	1.68	87	1661	1580	1243	.24	9.0	6.4	48 0	Effluent.
Oct.	10	42.8	23.2	84	1768	1720	1374	0	T	107 2	251.2	Manhole.
Oct.	10	23.8	12.8	95	1719	1523	1289	0	0	94.4	228.8	Tank.
Oct.	10	.24	.12	91	1701	1697	1430	.3	10.0	11.2	64.0	Effluent.
Oct.	17	16.6	9.6	70	1421	1347	1212	.4	0	16.0	145.6	Manhole.
Oct.	17	19.2	6.0	71	1545	1532	1275	0	0	40.0	174.4	Tank.
Oct.	17	.94	.96	75	1670	1538	1385	.1	8.0	4.8	51.2	Effluent.
Oct.	24	39.8	17.2	105	1620	1443	1276	0	0	240.0	332 8	Manhole.
Oct.	24	44.	28.2	100	1651	1592	1346	0	0	259.2	531.2	Tank.
Oct.	24	.32	.34	90	1642	1510	1282	.24	T	3.2	35.2	Effluent.
Oct.	31	25.9	20.8	99	1803	1520	1316	0	0	131.2	329.6	Manhole.
Oct.	31	24.9	9.7	119	1820	1757	1437	0	0	83.2	230.4	Tank.
Oct.	31	.16	.18	87	1580	1564	1336	.1	10.	4.8	46.4	Effluent.
Nov.	7	40.3	16 2	151	1747	1677	1407	.04	0	96.0	244.8	Manhole.
Nov.	7	18.2	8.5	103	1769	1686	1489	0	0	43.2	217.6	Tank.
Nov.	7	.68	.58	76	1800	1712	1623	.7	9.0	6.4	36.8	Effluent.
Nov.	14	16.3	7.4	71	1867	1752	1419	.4	0	35.2	251.6	Manhole.
Nov.	14	28.7	9.7	139	1562	1443	1356	0	....	134.4	198.4	Tank.
Nov.	14	1.08	.58	90	1743	1702	1441	.4	5.0	4.8	12.8	Effluent.
Nov.	21	34.7	164.7	1877	9330	8356	4157	0	T	1356.8	2656.0	Manhole.
Nov.	21	12.7	9.9	77	1660	1368	1205	0	0	153.6	249.6	Tank.
Nov.	21	1.78	.58	94	1696	1685	1455	.6	4.	6.4	8.0	Effluent.
Dec.	1	94.7	54.7	213	900	760	525	0	0	187.2	2.208	Manhole.
Dec.	1	10.4	6.9	98	1416	1384	813	.7	0	40.0	103.6	Tank.
Dec.	1	.12	.38	141	1588	1545	1260	.08	2.0	32.	54.8	Effluent.
Dec.	20	8.02	19.77	30	1658	1326	1043	0	0	134.4	219.2	Manhole,
Dec.	20	9.55	3.78	69	1160	1086	782	1.5	0	25.6	100.8	Tank.
Dec.	20	2 39	1.97	96	1061	1006	812	.5	2.0	9.6	54.4	Effluent.
1900												
Jan.	10	15 4	9.0	172	1548	1476	1154	.7	0	65.6	168.0	Manhole.
Jan.	10	34.0	26.2	133	1408	1237	953	T	0	132.8	219.2	Tank.
Jan.	10	5.28	2.0	73	1194	1016	851	.7	T	48.0	73.6	Effluent.
Jan.	19	20.7	30.4	1345	3772	3719	2908	0	T	158.4	412.8	Manhole.
Jan.	19	24.1	54.7	116	3385	2986	1870	0	0	412.8	627.2	Tank.
Jan.	19	6.14	1.84	100	1407	1361	1218	.4	.8	25 6	99.2	Effluent.
Jan.	24	7.0	17.3	755	3370	2770	201[illegible]	.0	T	209.6	472.4	Manhole.
Jan.	24	21.4	20.3	397	2495	2235	1746	.0	0	187.2	419.2	Tank.
Jan.	24	5.38	1.38	155	1895	1731	1421	1.0	.8	86.4	152.0	Effluent.
April	12	5.2	2.9	42	1426	1392	1178	.12	T	8.	29.2	Manhole.
April	12	12.7	4.7	48	1498	1450	1170	.08	T	27.2	41.6	Tank.
April	12	7.84	1.98	85	1646	1594	1346	.08	T	12.8	19.2	Effluent.
April	17	26.9	11.8	58	1464	1298	1124	.12	0	16.	30.	Manhole.

DATE.		AMMONIA.			SOLIDS.			NITROGEN AS		OXYGEN CONSUMED.		ORIGIN.
		Free.	Albuminoid.	Chlorine.	On evaporation.	At 180°.	On ignition.	Nitrites.	Nitrates.	Fifteen Min.	Four hours.	
April	17	17.4	3.9	47	1460	1314	1160	.2	T	10.8	13.2	Tank.
April	17	.84	.48	49	1378	1228	974	1.2	T	2.8	4.4	Effluent.
April	24	36.2	17.4	75	1520	1446	1152	0	0	16.4	42.	Manhole.
April	24	18.9	13.4	100	1980	1920	1528	0	0	28.	50.4	Tank.
April	24	8.08	.4	43	1480	1460	1246	.4	6.0	3.2	6.0	Effluent.
May	1	38.9	18.5	71	1720	1686	1326	0	T	21.2	40.8	Manhole.
May	1	17.4	2.9	46	1406	1356	1240	0	T	5.6	8.8	Tank.
May	1	.6	.3	70	1546	1532	1332	.2	16.	2.8	3.6	Effluent.
May	8	56.6	23.2	81	1734	1686	1246	0	T	28.8	44.16	Manhole.
May	8	9.7	4.2	48	1466	1406	1146	.2	T	11.84	12.8	Tank.
May	8	.44	.48	58	1540	[illegible]	1180	.24	20.	2.56	3.2	Effluent.
May	15	65.7	22.7	25	1384	830	456	.8	12.	16.0	31.04	Manhole.
May	15	44.0	3.4	50	1128	728	414	.9	4.	10.88	13.76	Tank.
May	15	8.44	.48	20	1070	838	556	.3	20.	.96	1.28	Effluent.
May	22	37.6	12.0	59	1088	988	668	1.2	8.	15.68	23.04	Manhole.
May	22	9.7	4.2	15	886	814	500	1.2	4.	9.92	12.48	Tank.
May	22	2.08	.68	28	1040	960	672	.2	20.	3.2	3.84	Effluent.
May	29	12.7	9.8	32	1144	1056	584	.6	4.	14.08	24.96	Manhole.
May	29	8.0	9.7	50	1036	996	510	.8	4.	15.04	33.28	Tank.
May	29	.84	.28	28	948	888	548	.16	30.	.96	1.28	Effluent.
June	5	8.0	19.3	118	1760	1540	666	0	T	80.96	101.44	Manhole.
June	5	23.5	10.3	38	1176	1108	480	0	T	18.88	41.28	Tank.
June	5	1.2	.24	37	1012	968	778	4.0	20.	1.28	1.92	Effluent.
June	15	2.7	12.3	36	4090	3950	3540	1.0	10.	23.04	41.60	Manhole.
June	15	7.0	5.7	95	3882	3730	3392	.6	4.	16.32	29.44	Tank.
June	15	.14	.1	32	3344	3296	3094	.04	20.	1.60	2.56	Effluent.
June	19	1.7	2.0	63	4236	4054	3802	.8	0	17.6	18.88	Manhole.
June	19	2.5	1.7	30	3246	3106	2880	.6	4.0	8.96	12.16	Tank.
June	19	.7	.54	12	[illegible]	2704	2510	.04	24.	.64	1.28	Effluent.
June	26	3.2	28.3	84	7360	7038	6404	.4	T	70.40	101.12	Manhole.
June	26	5.7	6.7	45	4230	4180	3900	.6	T	8.64	19.52	Tank.
June	26	.04	.04	10	3424	3362	3102	.24	15.	1.28	1.60	Effluent.
July	5	6.3	9.5	297	1111	1111	1111	1.0	T	11.84	14.40	Manhole.
July	5	4.2	1.7	28	......	......	......	.8	1.	3.2	5.42	Tank.
July	5	.7	.26	43	......	......	......	T	8.	.64	.96	Effluent.
July	12	7.5	2.1	20	......	......	......	.8	.8	9.92	13.12	Manhole.
July	12	3.2	17.	25	......	......	......	.4	1.4	4.48	4.80	Tank.
July	12	.44	.24	35	......	......	......	T	8.	.64	1.92	Effluent.
July	17	5.2	2.7	19	......	......	......	.6	.8	4.48	5.44	Manhole.
July	17	8.2	6.2	155	......	......	......	.6	1.	22.72	39.68	Tank.
July	17	.5	.1	15	......	......	......	T	8.	.32	1.92	Effluent.
July	23	3.5	5.0	30	......	......	......	.2	0	8.32	12.48	Manhole.
July	23	4.0	3.1	57	......	......	......	4.	0	6.72	8.00	Tank.
July	23	.2	.48	66	......	......	......	T	16.	.64	2.56	Effluent.
Aug.	1	1.0	3.5	16	......	......	......	.5	T	10.24	30.40	Manhole.
Aug.	1	2.3	1.7	14	......	......	......	.6	4.	......	6.40	Tank.
Aug.	1	0	.24	23	......			T	16.	......	3.20	Effluent.
Aug.	7	4.4	5.7	20	790	684	554	6.	3.2	32.	41.6	Manhole.
Aug.	7	1.2	4.0	17	820	780	568	.12	T	26.24	32.32	Tank.
Aug.	7	.4	.8	36	910	810	640	T	4.	4.48	11.20	Effluent.
Aug.	21	6.2	23.5	258	1574	1442	982	.84	0	5.44	28.80	Manhole.
Aug.	21	5.5	9.0	44	1288	1220	1054	.62	T	3.52	22.08	Tank.
Aug.	21	0	.24	41	812	766	516	.12	16.	.96	2.88	Effluent.
Sept.	5	2.1	6.1	43	1992	1592	1206	.40	0	14.40	24.00	Manhole.
Sept.	5	21.5	5.9	50	1814	1488	1140	.12	0	12.8	17.38	Tank.
Sept.	5	.1	.46	86	1720	1466	1194	.04	12.	.96	1.6	Effluent.
Sept.	12	6.2	5.7	43	1660	1600	1366	.4	0	4.16	6.08	Manhole.
Sept.	12	15.7	5.7	58	1460	1434	1180	0	T	8.32	9.28	Tank.
Sept.	12	.2	.26	54	1346	1280	1060	.04	16.	1.28	1.92	Effluent.
Sept.	17	16.0	16.0	96	2330	1852	1280	0	0	11.52	38.72	Manhole.
Sept.	17	10.3	12.6	95	1730	1524	1172	0	0	6.72	16.64	Tank.
Sept.	17	.16	.88	63	1384	1360	1048	.8	12.	.96	2.24	Effluent.
Oct.	2	9.0	12.6	63	2092	1952	1592	.4	0	9.20	31.04	Manhole.
Oct.	2	11.2	10.1	50	1940	1774	1580	.4	0	4.80	15.68	Tank.
Oct.	2	1.54	7.	54	1756	1476	1230	.4	10.	1.92	2.56	Effluent.
Oct.	8	29.6	12.8	58	1514	1460	1194	.4	0	6.40	9.28	Manhole.
Oct.	8	7.4	3.2	54	1292	1260	1006	.6	T	2.56	4.16	Tank.
Oct.	8	1.76	.44	55	1360	1340	1226	.8	8.	.96	1.28	Effluent.
Oct.	15	11.0	8.0	50	1468	1374	1194	.4	0	......	7.68	Manhole.

DATE.		AMMONIA.			SOLIDS.			NITROGEN AS		OXYGEN CONSUMED.		ORIGIN.
		Free.	Albuminoid.	Chlorine.	Evaporation.	At 180°.	On ignition.	Nitrites.	Nitrates.	Fifteen min.	Four hours.	
1900												
Oct.	15	14.8	8.2	42	1458	1308	1224	0	0	......	11.52	Tank.
Oct.	15	2.76		6	2388	2238	1978	0	16.	......	1.28	Effluent.
Oct.	22	42.1	30.0	166	1714	1546	12 4	.6	0	13.88	35.52	Manhole.
Oct.	22	8.1	2.9	57	1300	1248	1088	.6	0	8.32	15.04	Tank.
Oct.	22	.26	.40	61	1446	1414	1200	.6	16.	1.92	2.88	Effluent.
Nov.	5	4.9	4.5	57	1294	1208	1088	.8	4.6	5.12	8.64	Manhole.
Nov.	5	5.5	9.3	55	1192	1152	900	1.2	4.8	8.96	15.36	Tank.
Nov.	5	1.64	.42	55	1080	1074	880	.2	12.	.64	1.28	Effluent.
Nov.	12	6.3	4.0	55	1274	1194	1074	.4	4.0	5.76	11.52	Manhole.
Nov.	12	8.2	7.5	58	1428	1274	1130	.4	.8	10.88	21.12	Tank.
Nov.	12	.32	.26	55	1186	1126	1006	.24	16.	.96	1.28	Effluent.
Nov.	19	23.0	18.3	65	1474	1294	1074	0	.8	13.76	24.0	Manhole.
Nov.	19	11.4	3.3	43	1152	1088	906	.6	.8	2.24	3.84	Tank.
Nov.	19	.82	.62	50	1128	1088	980	.08	16.	.96	1.28	Effluent.
Nov.	26	13.6	8.7	58	1684	1500	1246	.2	1.2	10.88	19.84	Manhole.
Nov.	26	20.3	15.7	67	1648	1428	1174	.2	3.	16.	28.88	Tank.
Nov.	26	.68	.56	58	1414	1374	1114	.08	16	.96	1.28	Effluent.
Dec.	3	8.3	8.3	52	1300	1200	946	.2	T	6.72	12.48	Manhole.
Dec.	3	11.6	7.3	48	1360	1320	1046	.2	T	11.52	23.04	Tank.
Dec.	3	1.98	.46	50	1414	1374	1180	.16	12.	.64	.96	Effluent.
Dec.	17	27.7	19.1	62	1408	1394	1088	.2	0	30.76	52.16	Manhole.
Dec.	17	23.4	12.8	40	1488	1394	1080	T	0	25.92	49.92	Tank.
Dec.	17	5.84	1.36	50	1300	1130	980	.16	16.	1.60	5.76	Effluent.
1901.												
Jan.	8	6.7	21.6	62	1480	1422	1080	1.5	0	8.96	15.08	Manhole.
Jan.	8	3.2	8.3	55	1220	1208	1016	1.5	0	7.04	15.68	Tank.
Jan.	8	1.84	1.36	45	1214	1164	1020	.24	12	2.56	4.80	Effluent.
Jan.	14	13.5	110.8	95	3800	3420	1772	.6	0	78.44	380.2	Manhole.
Jan.	14	10.7	13.0	52	1200	1168	972	.04	0	15.6	38.0	Tank.
Jan.	14	.94	1.92	55	1368	1218	1144	0	0	1.28	2.80	Effluent.
Jan.	21	7.9	13.8	62	1670	1576	1162	.5	0	18.88	60.80	Manhole
Jan.	21	5.2	20.1	62	1478	1414	1008	0	0	15.04	59.68	Tank.
Jan.	21	.44	1.36	50	1258	1242	1086	T	10.	1.28	1.60	Effluent.

DATE.	AMMONIA.			SOLIDS.			NITROGEN		OXYGEN CONSUMED.				ORIGIN.
	Free.	Albuminoid.	Chlorine.	On evaporation.	At 180°.	On ignition.	As nitrites.	As nitrates.	Three min.	Fifteen min.	Four hours.	Association method.	
Jan. 28	16.4	15.1	91	2548	2486	2088	.04	T	......	19.84	42.88	......	Manhole.
Jan. 28	17.9	15.6	60	1270	1252	1026	.1	.8	......	29.12	44 48	......	Tank.
Jan. 28	2.5	1.32	54	1358	1346	1142	T	10.		.96	2.88		Effluent.
Feb. 5	19.7	25.3	40	1156	1044	560	.40	1.0	1.57	38.12	....	155.6	Manhole.
Feb. 5	9.7	8.5	40	696	662	516	.30	1.	.39	16 32	19.9	31.6	Tank.
Feb. 5	.94	1.2	45	854	838	688	T	2.0	.19	1.2	3.6	10.	Effluent.
Feb. 11	7.7	13.3	70	1800	1600	1066	T	0	.59	6.4	31.4	145.6	Manhole.
Feb. 11	8.9	5.8	66	1266	1180	906	.04	T	.19	2.4	....	46.8	Tank.
Feb. 11	1.32	1.16	72	894	814	654	.04	6.0	.19	.4	3 60	4.	Effluent.
Feb. 19	22.4	21.0	85	1850	1794	1326	.08	0	1.37	24.0	68 4	103.2	Manhole.
Feb 19	14.4	13.2	65	1234	1196	966	.1	T	.59	1.0	9.2	40.4	Tank.
Feb. 19	2.72	1.62	50	1290	1282	1098	.20	6.0	.05	....	.4	6.8	Effluent.
Feb. 26	25.7	39.8	89	2112	2078	1234	0	0	.98	54.2	76.6	240.4	Manhole.
Feb. 26	28.4	16.1	68	1338	1314	1116	0	0	.59	4.6	10 8	34.20	Tank.
Feb. 26	4.06	2.58	72	1440	1402	1260	.16	6.0	.39	....	.4	6.8	Effluent.
March 4	24.0	16.3	78	1322	1300	1078	.04	0	.39	9.6	11.6	67.2	Manhole.
March 4	11.2	10.5	59	1170	1158	896	.08	T	.39	8.6	2.9	42.	Tank.
March 4	6.24	2.82	65	1302	1132	1006	.32	4.0	.39	5.2	7.6	18.	Effluent.
March 28	25.8	18.3	88	1396	1316	1046	.15	T	2.75	....	38.42	37.58	Manhole.
March 28	13.8	9.6	59	1212	1164	934	.1	T	2.56	9.8	29.56	58.08	Tank.
March 28	5.04	1.26	59	1336	1304	1298	.08	12.	1.18	....	......	7.26	Effluent.
April 4	19.6	9.1	56	1340	1270	1024	.15	0	2.16	.....	19.7	25.4	Manhole.
April 4	17.6	11.1	53	1142	1098	932	.18	.4	1.57	....	11.82	34.49	Tank.
April 4	4.1	2.8	67	1244	1206	1060	.06	4.0	.78	....	1.97	6.89	Effluent.
April 11	9 2	12.4	47	1350	1286	1062	.10	T	1.18	2.22	10.09	34.49	Manhole.
April 11	12.6	12.4	51	1324	1268	1018	.08	T	1.18	6.75	12.83	49.65	Tank.
April 11	4.7	1.4	54	1270	1242	840	.18	4.0	.28	.63	1.37	5.45	Effluent.
April 19	8.4	10 4	52	2490	1874	1570	.04	0	2.75	10.07	22.	102.00	Manhole.
April 19	12.0	13.6	44	1244	1240	1234	.12	T	1.97	7.41	18.2	47.27	Tank.
April 19	5.56	1.96	45	1112	1110	1022	.08	6.0	0	1.77	3.58	3.26	Effluent.
April 26	14.6	9.6	55	1348	1328	984	.4	0	5.12	54.4	63.16	178.80	Manhole.
April 26	13.8	10.4	46	1162	1124	924	.6	0	1.77	8.89	18.33	53.36	Tank.
April 26	7.32	,96	45	1228	1206	994	.30	14.	0	.59	1.57	5.45	Effluent.
May 2	4.8	12.6	55	2988	2922	2250	.2	0	1.81	6.11	56.77	89.6	Manhole.
May 2	10.2	10.0	69	1684	1678	1224	0	0	1.51	2.36	42.67	87.4	Tank.
May 2	4.42	.5	49	1310	1292	1098	.12	14.	.03	.72	2.16	4.27	Effluent.
May 9	15.8	11.6	62	1792	1546	960	0	0	2.75	16.6	22.392	91.9	Manhole.
May 9	17.0	7.0	51	1260	1236	960	.15	05	1.57	7.84	10.54	26.49	Tank.
May 9	1.8	.6	61	1372	1358	1038	.04	12.	.79	.168	1.9	6.1	Effluent.
May 16	22.	32.5	67	1930	1890	1530	T	0	3.94	14.7	34.89	90.7	Manhole.
May 16	21.0	32.5	94	1910	1904	1380	.02	0	3.15	16.24	44.52	132.1	Tank.
May 16	1.38	1.06	65	1570	1570	1282	.16	14.	.79	.906	1.96	4.3	Effluent
May 23	38.	28.	68	1890	1868	1234	0	0	5.51	25.8	83.20	170.6	Manhole.
May 23	39.5	24.	84	1278	1248	1066	.3	0	.19	9.8	18.	45.7	Tank.
May 23	1.38	.55	59	1232	1226	1082	.12	12.	1.18	1.34	.	8.3	Effluent.
May 30	32.0	17.0	88	1886	1832	1246	.04	0	2 36	12.81	31.3	95.1	Manhole.
May 30	24.	14.	68	1230	1204	1034	.08	0	1.57	5.54	.	22.5	Tank.
May 30	1.44	.58	66	1440	1436	1310	.30	20.		.53	3.58	6.53	Effluent.
June 6	17.5	17.	60	1736	644	1162	.1	0	1.77	15.8	38.39	132.85	Manhole.
June 6	31.	18.	66	1336	1220	1068	.15	T	1.57	7.1	13.26	19.60	Tank.
June 6	1.04	.66	73	1536	1512	1268	.04	18.	.....	.26	1.76	3.99	Effluent.
June 13	55.5	25.	63	2096	2096	1330	0	0	3.94	41.90	124.91	362.27	Manhole.
June 13	....	10.	43	1224	1224	1080	0	0	.15	5.16	7.25	27.59	Tank.
June 13	1.98	1.4	70	1612	1596	1352	.1	24.	.78	3.64	6.40	18.10	Effluent.
June 20	16.5	11.5	59	1236	1226	1068	.2	0	.39	1.67	7.4	23.6	Manhole.
June 20	1.0	6.5	67	1600	1432	127-	.4	0	.58	......	2.28	30.8	Tank.
June 20	.7	.42	44	1130	1114	966	.06	12.	.39	.40	5.6	12.	Effluent.
June 28	56.	257.	136	5094	4406	1952	0	0	9.6	127.63	272.6	483.6	Manhole.
June 28	10.5	5.5	44	1302	1274	1100	0	0	1.41	5.64	10.63	25.2	Tank.
June 28	1.14	.2	60	1540	1514	1380	0	24.	.49	1.27	2.40	5.2	Effluent.
July 5	15.5	26.5	22	1618	1580	1212	.04	0	1.41	6.77	20.60	48.4	Manhole.
July 5	10.5	8.	52	1242	1218	1112	.2	0	1.55	2.88	5.09	13.2	Tank.
July 5	.28	2.15	27	1510	1466	1396	T	20.	1.14	1.14	1.71	6.0	Effluent.
July 11	8.5	8.5	94	5824	5788	5498	.04	0	1.13	15.69	41.77	122.8	Manhole.
July 11	23.	28.5	54	1848	1804	1290	0	0	2.09	17.92	75.73	156.	Tank.
July 11	.1	.32	70	1524	1496	1334	.2	12.	.56	.97	2.97	7.6	Effluent.
July 18	14.	7.50	98	2120	2080	1820	0	T	1.83	8.4	16.68	48.	Manhole.
July 18	12.50	7.50	69	1114	960	782	0	0	2.97	10.80	18.6	44.0	Tank.
July 18	1.36	1.44	48	1472	1420	1332	.2	16.	1.13	2.3	4.26	5.6	Effluent.

DATE.		AMMONIA.			SOLIDS.			NITROGEN		OXYGEN CONSUMED.				ORIGIN.
		Free.	Albuminoid.	Chlorine.	On evaporation.	At 180°.	On ignition.	As nitrites.	As nitrates.	Three min.	Fifteen min.	Four hours.	Association method.	
July	25	26.5	32.	50	1650	1590	1206	0	0	2.25	25.16	49.78	127.6	Manhole.
July	25	27.50	11.50	74	1618	1588	1280	0	0	20 99	28.55	46.54	72.0	Tank.
July	25	.66	.7	87	1472	1468	1322	0	8.	1.42	1.50	1.63	4.0	Effluent.
Aug.	1	20.	31.5	71	1408	1360	1190	.04	0		10.586	24.13	57.20	Manhole.
Aug.	1	16.5	17.5	98	1714	1676	1370	0	0	......	29.26	59.31	95.60	Tank.
Aug.	1	.64	5.5	97	1342	1326	1234	0	8.	......	2.117	......	6.00	Effluent.
Aug.	9	10.5	47.	37	876	870	752	.4	.8		1.35	5.62	16.80	Manhole.
Aug.	9	12.5	17.5	51	660	652	552	0	0	1.809	4.87	12.71	44.00	Tank.
Aug.	9	.96	1.8	50	1318	1314	1194	0	4.	......	.	2.27	4.00	Effluent.
Aug.	15	25.	24.50	57	952	924	772	.04	0	1.99	8.59	11.24	35.60	Manhole.
Aug.	15	29.00	24.00	65	1392	1372	1184	0	0	4.52	11.54	23.55	35.20	Tank
Aug.	15	.64	1.04	48	1420	1404	1332	0	20	.72	.6[illegible]	2.56	3 20	Effluent.
Aug.	22	36.	81.5	21	2686	2276	. .	0	0	1.26	33.31	178.00	357.60	Manhole.
Aug.	22	25.5	66.	25	1356	1320	1180	T	0	2.53	6.396	14.02	26.80	Tank.
Aug.	22	.76	.36	15	1398	1370	1240	0	16.	.72	.72	1.93	4 40	Effluent.
Aug.	29	34.	16.	48	1648	1546	1270	0	0	3.79	10.07	29.40	65.20	Manhole.
Aug.	29	17.	0	72	1310	1270	1126	0	0	1.99	3.94	11.02	43.60	Tank.
Aug.	29	.5	.5	64	1442	1408	1088	0	24.	.72	.72	1.26	2.40	Effluent.
Sept.	4	51.	42.5	62	1584	1522	1228	.4	0	5.00	36.40	47.52	102.80	Manhole.
Sept.	4	18.	30.	26	1124	1074	920	0	0	1.80	8.70	8.74	13.20	Tank.
Sept.	4	.55	.08	38	1054	844	.....	0	12.	.60	.60	2.04	2.40	Effluent.
Sept.	13	51.5	7 5	68	1504	1464	1220	T	0	1.80	11 44	19.18	12.00	Manhole.
Sept.	13	54.5	17.5	54	1428	1366	1112	0	0	2.60	8.06	15.15	25.20	Tank.
Sept.	13	.136	.5	47	2020	2014	1008	0	12.	.40	2.30	4.78	12.40	Effluent.
Sept.	20	35.0	32.0	70	1758	1658	1478	.04	0	13.40	37.40	52.96	144.80	Manhole.
Sept.	20	40.5	15.0	55	1266	1238	1120	0	0	2.20	8.96	15.4[illegible]	35.60	Tank.
Sept.	20	.46	1.16	54	1448	1432	1304	.04	12.	.90	.90	1.3[illegible]	2.00	Effluent.
Sept.	25	28.5	19.0	.	1414	1382	1186	.08	....	.[illegible]0	4.52	13.22	24.80	Manhole.
Sept.	25	43.5	17.[illegible]	..	.420	1378	1[illegible]90	0		6.00	11.52	21.12	29.20	Tank.
Sept.	25	.68	.70	...	1582	1446	1330	T	....	0	.63	2.12	4.40	Effluent.
Oct.	2	21.0	9.5	...	1266	1262	1166	.08	....	......	.80	3.34	8.40	Manhole.
Oct.	2	20.5	22.0	...	1326	1284	1158	.06	.	......	5.40	7.80	17.60	Tank.
Oct.	2	44	.48	..	1486	1412	1322	T			.80	1.40	1.60	Effluent.
Nov.	4	21.0	25.5	80	1792	1582	1360	.04		3.20	16.64	19.68	109.20	Manhole.
Nov.	4	43.5	32.5	64	1816	1808	1298	.02	...	1.60	15.68	45.76	103.30	Tank.
Nov.	4	1.6	.18	54	1294	1292	1194	T		.00	.36	.57	4.40	Effluent.
Dec.	11	39.	14.5	94	1522	1464	1304	.12	T	1.57	3.41	27.75	38.40	Manhole.
Dec.	11	41.	42.	68	1500	1436	1262	.12	0	3.93	7.46	28.29	31.46	Tank.
Dec.	11	2.36	4.5	59	1528	1500	1432	T	8.	.39	1.02	1.75	3.80	Effluent.

It is a well known fact that the simplest and best method of destroying organic matter, that is liable to provide favorable conditions for the growth of disease germs, is to destroy it by burning or oxidation. If the matter is in a solid condition and dry naturally, burning is the most suitable. If in solution and a large quantity of water is present other means must be used. The modern process of bacterial purification of sewage is therefore simply using the nitrification process to oxidize the organic matter and ultimately changing the nitrogenous matter to nitric acid. The raw sewage or that which is designated as the manhole sample contains the organic matter in its most stable form. The raw sewage on passing into the septic tank undergoes a process which is complicated from a chemical

point of view and by many it has been called a digestion process. The organic matter in the sewage after it has remained in the tank for some time, undergoes a change which prepares it so that it can be oxidized much more readily in the nitrification process. As an illustration to show the changes which the sewage has undergone, the results of the determination of free ammonia may be taken. The results taken are for the cubic centimeters of the standard ammonia as determined by each tube.

NUMBER OF TUBE.	MANHOLE.	TANK.	EFFLUENT.
1	31.5	11.	3.3
2	7.5	3.	.8
3	3.	1.2	.2
4	2.2	.8	.2
5	1.0	.5	.0
6	1.2	.5	
7	1.0	.3	
8	.7	.2	
9	.7	.2	
10	.8	.0	
11	1.0		
12	.8		
13	.5		
14	.8		
15	1.0		
16	1.2		
17	.8		
18	.8		

It will be noticed that after the distillation of 18 tubes in the manhole sample the free ammonia showed no signs of decreasing or is there any period in the analysis where the distillation of the free ammonia may be said to be complete. In the tank sample ten tubes were only required for the complete distillation of free ammonia while the effluent was complete with five tubes. Another interesting change which takes place as the result of the decomposition in the septic tank is in the determination of solids. In the solids at 180° C. it is noticed that the residue in the manhole sample is quite black and shows very strongly that organic matter is present. The sample from the tank in contrast gives very readily a grayish or nearly white residue. The chemical changes which take place in the septic tank are very complicated and offer a field for special research.

The sewage of the college is generally very concentrated when compared with the sewage of other places. The sewage analyzed by the Massachusetts state board of health gave the following interesting results:

	PARTS PER MILLION.		
	Lawrence.	Framingham.	Gardner.
Chlorine	119.0	64.2	42.0
Solids on evaporation	....	1031.	508.
Loss on ignition	....	676.	345.
Albuminoid ammonia	10.2	10.2	9.8
Free ammonia	34.7	26.4	29.8
Nitrites	0.18	0.26	0.01
Nitrates	1.56	0.14	0.06
Oxygen consumed	90.2	97.9	57.3

While the college sewage is more concentrated than that of many of the larger cities in the East, that of some of the western cities which contain manufactures may be expected to have sewage stronger than that of the college. In a recent investigation of the sewage of Marshalltown the following results were obtained and will show the composition of sewage of this nature:

	DATE SAMPLE TAKEN.			
	March 22, 1900, 2 P. M.	March 22, 1900, 8 P. M.	March 23, 1900, 2 A. M.	March 23, 1900, 8 A. M.
Chlorine	84	84	52	34
Total solids	1460	3480	1000	1940
Solids after drying at 180° C	900	2160	660	1400
Solids after ignition	580	1560	560	960
Albuminoid ammonia	16.0	6.6	3.4	37.0
Free ammonia	8.0	5.2	1.0	8.6
Nitrites	T	0.8	0.2	0.16
Nitrates	0	0	1.6	0.8
Oxygen consumed (15 min.)	* 358.4	* 108.8	* 16.0	* 60.8
Oxygen consumed (4 hours)	* 556.8	* 345.6	* 22.4	* 256.0
Acidity (NaOH to neutralize)	48	256	56	56

*These results obtained by different methods, giving much higher results than that used for state college. (The temperature of the determination being 80° C.)

In addition to the above the following analyses of Mt. Pleasant and Grinnell sewage will serve to show the composition of sewage from the smaller cities of the state.

	MT. PLEASANT.	GRINNELL.
Chlorine	165.	96.
Solids on evaporation,	5402.	1010.
Solids at 180° C	5332.	906.
Solids on ignition	1450.	664.
Albuminoid ammonia	31.5	10.0
Free ammonia	53.5	13.6
Nitrites	0.0	0.8
Nitrates	0.0	4.0
Oxygen consumed, 3 minutes	32.6	1.18
Oxygen consumed, 15 minutes	34.62	8.4
Oxygen consumed (4 hours)	45.46	10.30
Oxygen consumed, Asso. meth	94.40	20.7

The water used by the college is furnished from a well 2,215 feet deep and a recent sanitary analyses gave the following results:

	PARTS PER MILLION.
Free ammonia	.18
Albuminoid ammonia	.024
Chlorine	51.
Solids on evaporation	1226.
Solids at 180° C	1180.
Solids on ignition	1040.
Nitrogen as nitrites	.4
Nitrogen as nitrates	T.
Oxygen consumed, 15 minutes	.32
Oxygen consumed, 4 hours	.48

The large amount of solids and of chlorine increases the amount of these substances in the results obtained from the sewage and should be considered when comparisons are made with the sewage from other localities.

The chemical composition of the sewage is of great importance, but the test of its purification is the composition of the effluent. Some effort has been made to establish standards for the effluents, and the limit allowed by the Mersey and Irwell Joint Committee is that the effluent shall not absorb over one grain of oxygen per gallon in four hours (one grain per imp. gallon equals 14.3 parts per million). The same committee limits the albuminoid ammonia in the effluent to .1 grain per gallon, or 1.43 parts

per million. From an examination of the results it will readily be seen that the college effluent meets these requirements with a few exceptions. The exceptions where the albuminoid ammonia is especially high results from the extra work required from the beds when the amount of sewage is increased by storm water. When comparing the results of the oxygen absorption, attention may be called to the fact that previous to April 17, 1900, the temperature at which the determinations were made was 80° C. and after that date 80° F. as recommended by the Society of Public Analysts of England. The results made since April 17, 1900, are directly comparable with the results of the English investigations and it will be seen that the results readily meet the limit of the Mersey and Irwell Joint Committee. Since June 28, 1901, the determinations made of oxygen absorption have been the 3 minute test, the 15 minute test, the 4 hour test and the Association test. The object of the first three tests may be explained by the following statement of Mr. Frank Scudder before the Society of Chemical Industry.

The object of using these various time tests is to differentiate the quality of the organic matter and in order to make the point clear, he (Mr. Scudder) divided the quality of the organic matter in the Safford effluents into three divisions as follows:

I. The three minute test showed the putrid matter decomposing permanganate at once with acid. Angus Smith said that this test measured the organic matter decomposed or putrid or at least certain gases which it left behind capable of decomposing permanganate.

II. The fifteen minute test, that is fifteen minutes less the three minute test equals a twelve minute test, showed ma ter readily putrefying and rapdly decomposing permanganate with acid. Angus Smith classed this as organic matter readily decomposed and probably ready to become putrid.

III. The four hour test minus the 15 minutes and minus the 3 minute test which equals a 225 minute test for the action of the permanganate, showed matter capable of putrefying, although slow to decompose.

It is a matter of interest in connection with the three minute test that in addition to the organic matter decomposed, nitrites and ferrous iron or hydrogen sulphide if present react upon the permanganate.

The explanation of the object of the time tests shows that the results indicate to a certain extent the condition of a part of the organic matter present in the sewage, but these tests do not indicate the action on the entire quan-

tity of organic matter which may be present in the sewage and not in a decomposing state. In order to obtain a result which will indicate the action of the permanganate on the organic matter that is not in a more or less decomposing state a method must be used where the conditions are more favorable for the oxidizing agent, and for this reason the association method is used to complete the series of determinations.

The effluent naturally is high in nitrogen as nitrates yet it is not as bad as the water furnished by some shallow wells and which is sometimes used for household purposes. For comparison the following analysis of water from a shallow well may be of interest. The analysis is from a recent investigation: *

	PARTS PER MILLION.
Free ammonia	.104
Albuminoid ammonia	.086
Solids on evaporation	874.
Solids at 180°	714.
Solids on ignition	506.
Nitrogen as nitrites	.16
Nitrogen as nitrates	40.
Oxygen consumed in 15 minutes	.64
Oxygen consumed in 4 hours	.96
Chlorine as Chlorides	26.

The results of the investigation of the College Sewage Plant indicates that the purification of the sewage from the towns and cities by the bacterial method is possible under the conditions present in the state. The fact that the sewage is more concentrated than that of many other localities does not prevent the production of an effluent which will meet any reasonable standard for purity.

*A study of a contaminated water supply. Weems and Brown. Proceedings of the Iowa Academy of Sciences. Vol. 7, p. 91.

MENKE'S METHOD OF PREPARING HYPONITRITES.

BY ALFRED N. COOK.

Hyponitrites were first prepared in 1871 by Edward Divers* by reducing an alkaline nitrate in water solution by means of sodium amalgam. About seven years later A. E. Menke†, of Kings College, London, obtained a compound by heating cast iron filings with sodium nitrate which Professor Bloxam suggested to be the compound discovered by Dr. Divers. An analysis of the sodium determined as sodium sulphate and an analysis of the nitrogen determined as ammonia yielded the theoretical amounts of these elements, all within the limits of experimental error. On drying at 100° C. it lost in weight corresponding to three molecules of water of crystallization. He also prepared the silver salt and analyzed it, and the results corresponded to theory.

Some time since, while engaged in the study of "hyponitrites", I endeavored to prepare sodium hyponitrite by Menke's method. It appealed to me as being the cheapest and most convenient, and as one that would give a large yield. I obtained a crystalline, fluorescent salt which, when dried at 100° C. lost in weight corresponding to four molecules of water of crystallization. It yielded on analysis the theoretical amount of sodium in sodium hyponitrite. When a water solution was treated with a solution of silver nitrate, it yielded a precipitate which had the appearance of the silver salt of hyponitrous acid described by Dr. Divers. On analysis it yielded the theoretical amount of silver in silver hyponitrite. On treating the

*Journal of the London Chemical Society, 1871, 484.
†Journal of the London Chemical Society, 1878, Transactions, 401.

sodium salt with an acid, however, it did not evolve nitrous oxide but carbon dioxide. It did not yield nitrogen by any of the common qualitative tests. I also attempted to determine the amount of nitrogen by the absolute method but found none. The salt obtained was therefore a carbonate. The fact that the sodium and the silver, obtained by the analysis of the respective salts, correspond to both carbonate and hyponitrite, is explained by the fact that hyponitrous acid and carbonic acid have the same molecular weight.

$$H_2N_2O_2 = 2+28+32 = 62.$$
$$H_2CO_3 = 2+12+48 = 62.$$

I endeavored to prepare sodium hyponitrite by this method repeatedly, varying the conditions each time, but always with the same result.

In view of the above experiments there are several other reasons that would lead one to suspect that Menke obtained sodium carbonate instead of sodium hyponitrite.

First.—Like sodium carbonate, Menke's salt was an efflorescent substance. It contained six molecules of water of crystallization (using the double formula), but sodium carbonate, under varying conditions, crystallizes out with one, two, five, six, seven, ten or fifteen molecules of water.

Second.—Menke obtained the best yield by keeping the crucible at a red heat for an hour after deflagration ensued. This might be explained on the ground that it would give more time for the oxidation of the carbon in the iron, which exists very largely as graphite and which is completely oxidized to carbon dioxide only by long continued heating with sodium nitrate. A great deal of carbonate must have been formed during the process, especially in view of the fact that cast iron was used, which contains from 2 to 5 per cent of carbon. The carbon in uniting with sodium and oxygen would produce nearly nine fold its own weight of sodium carbonate, or for every 100 grams of iron employed there would be produced from eighteen to forty-five grams of sodium carbonate, providing there was sufficient sodium to combine with it. While there would

be only one-half the amount of sodium present to produce this much carbonate, and in practice there would be much less produced than theory would indicate, there must still have been a large amount of this salt to deal with.

Alkaline nitrites have the power of absorbing carbon dioxide and giving off oxides of nitrogen, thus changing spontaneously into carbonates when conditions are favorable. It is also well known that nitrates are changed into nitrites by the action of many reducing agents. In the light of the above, then, the first step would probably be the changing of the nitrate to nitrite by the reducing action of the iron. In the second step the carbon dioxide which has been formed replaces the "N_2O_3" in two molecules of sodium nitrite.

Third.—The precipitates which Menke's sodium salt yielded with various salts of the heavy metals are quite different from those described by Divers, and quite identical with those yielded by a solution of sodium carbonate.

DIVER'S HYPONITRITE.

Copper sulphate gives a yellowish, olive green precipitate.

Lead acetate gives a cream white, floculent precipitate.

Mercuric chloride gives a cream white floculent precipitate.

Mercurous nitrate gives a blackish, gray precipitate.

Nickel chloride gives a greenish, almost white, precipitate.

Manganese chloride gives a nearly white precipitate.

Ferric chloride gives a reddish-brown precipitate.

Ferrous sulphate gives a whitish precipitate which instantly changes to a dirty, blackish green.

Zinc chloride gives a white precipitate.

Barium chloride gives no precipitate.

MENKE'S "HYPONITRITE."

Copper sulphate gives a torquois blue precipitate.

Lead acetate gives a white precipitate.

Mercuric chloride gives a white precipitate which becomes yellow and then brownish-red.

Mercurous nitrate gives a black precipitate.
Nickel sulphate gives a whitish-green precipitate.
Manganese chloride gives a white precipitate.
Ferric chloride gives a yellow precipitate.
Ferrous sulphate gives an olive green precipitate.
Zinc chloride gives a white precipitate.
Baryta gives a white precipitate.

SODIUM CARBONATE.

Copper sulphate gives a turquois blue precipitate.
Lead acetate gives a white precipitate.
Mercuric chloride gives a light yellow precipitate which turns brownish red.
Nickel sulphate gives a whitish green precipitate.
Manganese chloride gives a white precipitate.
Ferric chloride gives a brown precipitate.
Ferrous sulphate gives an olive green precipitate.
Zinc chloride gives a white precipitate,
Barium chloride gives a white precipitate.

It will be observed that the only essential difference in the precipitates yielded by "Menke's hyponitrite" and sodium carbonate is in case of ferric chloride which yields a brown precipitate instead of a yellow one, and that might even be described as yellow in dilute solution.

We presume that Menke did his work under the eye of Professor Bloxam, and he did not seem to doubt it in any way. In his text-book on Inorganic and Organic Chemistry, page 145, he states that "the sodium salt may be prepared in large quantity by fusing sodium nitrate with iron filings in an iron crucible."

It may be said that other methods have failed in the hands of those who followed the discoverer. Zorn prepared alkaline hyponitrite by reducing nitrates with ferrous hydroxide, but for some years afterwards, those who followed him failed in their attempts to apply his method. Notwithstanding all that can be said in favor of Menke's method, while it is still possible, it would seem evident that he mistook sodium carbonate for sodium hyponitrite.

CALCIUM CARBIDE AS A DEHYDRATING AGENT FOR ALCOHOLS.

BY ALFRED N. COOK AND ARTHUR L. HAINES.

It is well known that almost all alcohols purchased in the market contain considerable water. It varies from five per cent. to fifteen per cent. in methyl and ethyl alcohols and is less in amyl and other alcohols. It was thought that it would be interesting and profitable to determine the degree of dehydration produced by the action of calcium carbide on the water in these alcohols. In the reaction acetylene is evolved and calcium oxide is formed according to the following equation.

$$CaC_2+2H_2O = CaO+2C_2H_2.$$

Several methods have been suggested, and employed to a limited extent, for the quantitative estimation of alcohols, but only one or two of them have come into general use. The method used for determinining the degree of dehydration in this work was to ascertain the specific gravity of the alcohol at 15.5° C., and then compare the result with a specific gravity table. All of the usual precautions as to temperature, etc., that are common to this method, were employed.

Methyl Alcohol. About the only dehydrating agents heretofore used for methyl alcohol are anhydrous copper sulphate, anhydrous potassium carbonate, and calcium oxide. Methyl alcohol combines with calcium chloride and barium oxide to form alcohol of crystallization, similarly to water, which fact prevents their being used as in case of

ethyl alcohol. Calcium carbide also combines with methyl alcohol, but not at the temperature of the boiling alcohol.

In one experiment, 500 grams of methyl alcohol, the specific gravity of which was .820 as shown by the hydrometer (and which was therefore a 91 per cent. alcohol) was treated with powdered, commercial calcium carbide. The amount necessary was calculated from the equation given above, and 20 per cent. was added to this in order to provide for the impurities in the carbide and still leave an excess. An evolution of acetylene began which rapidly increased and the heat of reaction raised the temperature of the alcohol to its boiling point, so that it became necessary to attach a return condenser to prevent the loss of the alcohol. The flask was thoroughly shaken occasionally during the reaction. When the action, which required four or five hours had ceased, the flask and contents were placed on a water bath and the alcohol boiled with a return condenser for some time in order to drive off as much acetylene as possible as it is quite soluble in methyl alcohol. It was then distilled off with the usual precautions to keep out the moisture of the air. All parts of the distillate still contained considerable acetylene and anhydrous copper sulphate was added to remove it. The flask was thoroughly shaken and the alcohol redistilled. The first portion of the distillate was rejected as it still smelled strongly of acetylene. The specific gravity of this specimen was not taken but it must have been completely dehydrated, since it dissolved anhydrous copper sulphate with the formation of the blue solution* of the formula, $CaSO_4 + 2CH_4O$. This takes place only with perfectly anhydrous methyl alcohol.

Dr. Theodore Schuchardts c. p. methyl alcohol (which had a specific gravity of .8187, and which was therefore a 92 per cent. alcohol), when treated with calcium carbide evolved acetylene rapidly. When it had reached the point where calcium carbide ceased to act upon it, it still had a specific gravity of .8046. The density of the absolute

*Klepl, Ber. der Deut. Chem. Ges. p 15, R, 2361; and de Forcrand, *Ibid.*, XIX. R, 236.

alcohol is given as .8021.* This would indicate either that the alcohol was not absolute (the specific gravity obtained corresponds to a 99 per cent. alcohol), or that the specimen experimented upon was not quite pure. From the fact that it gives the reaction of de Forcrand and Klepl mentioned above, one would be justified in concluding that the latter was true, and that the alcohol was entirely anhydrous.

Ethyl Alcohol. It has always been considered difficult to remove the last traces of water from ethyl alcohol. On account of the importance of absolute alcohol it was one of the first subjects to receive the attention of the early chemists and a number of good methods for dehydrating ethyl alcohol were in use more than a century ago. In the year 1788 the British government employed a chemist by the name of Gilpin to work on the subject. He succeeded in obtaining alcohol of specific gravity .7939 at 60 degrees Farenheit. This was a remarkably good result for that time. The specific gravity of ethyl alcohol is now usually considered to be .7938. One experimenter,† however, claims to have prepared an alcohol of specific gravity .7935.

The common dehydrating agents for ethyl alcohol are calcium chloride (for removing the first portion of water), anhydrous potassium carbonate, anhydrous potassium acetate, anhydrous copper sulphate, metallic sodium, phosphoric anhydride, barium oxide, and calcium oxide. Drinkwater,‡ about 1860, and Mendeleeff,§ in 1865, showed that calcium oxide was superior to all dehydrating agents then in use.

The term "absolute alcohol" is frequently used to indicate any alcohol that is stronger than can be obtained by simple fractional distillation and which still contains considerable water. Most of the absolute alcohol of the best grade contains some water. A specimen at hand from Sargent & Company evolves some acetylene when warmed with powdered calcium carbide.

*Allen's Com. Org. Anal., Vol. I, page 71.
†Allen's Com. Org. Anal., Vol. I, page 85.
‡Dr. Sheridan Musprat's Chemistry, Vol. I, pages 51-52.
§Jour. Lond. Chem. Soc., 1871, 138.

In the preparation of absolute ethyl alcohol precisely the same method was used as is given above for methyl alcohol, except that it was not found necessary to use the return condenser during the action of the calcium carbide, on account of the higher boiling point of ethyl alcohol. In one experiment where extra precautions were not taken against loss by evaporation, 700 grams of absolute alcohol were obtained from 1,000 grams of an 89 per cent. alcohol.

A specimen of Sargent's "95 per cent. alcohol," which had a specific gravity of .8183 at 15.5 degrees C. (and which was therefore a 92.7 per cent. alcohol), when dehydrated, had a specific gravity of .79357 on the average. This corresponds with the lowest figures obtained by Squibs and Mendeleeff, and it would indicate that it was entirely dehydrated. The fact that Yvon¶ has also prepared absolute ethyl alcohol by this method was overlooked until after the above work was completed. The yield of alcohol is very much diminished by decanting from the residual calcium hydroxide, as he did, instead of distilling it off, since fully one-third of the alcohol is held mechanically by the bulky residue.

Butyl Alcohol. The specimen of alcohol used was from Merck & Company. It had a boiling point of 104 degrees C. and a specific gravity of .8059. When treated with calcium carbide it evolved acetylene when slightly warmed. When the action was complete it had a specific gravity of .8043 at 15.5 C. It was found very unsatisfactory to compare this result with the specific gravities given, as various investigators have obtained results which differ widely. Of the four specific gravities we find given for butyl alcohol, it is higher than one, but lower than three of them. The burden of evidence is therefore in favor of its being entirely dehydrated.

Amyl Alcohol. A specimen of Dr. Theodore Schuchardt's alcohol, that had a specific gravity of .8163 (which would of itself indicate that it contained considerable water) evolved acetylene rapidly when treated with calcium carbide and heated to 100 degrees C. When the action was

¶Compt. Rend. 1897, 1181, 1182.

complete it had a specific gravity of .8131. The specific gravity of the anhydrous alcohol* is given as .8148.

From the results given above it will readily be seen that calcium carbide affords a good test for water in alcohols, since it acts upon aqueous alcohol as long as any water remains in it with the evolution of acetylene, especially when slightly warmed. One would also be warranted in concluding that calcium carbide deserves to be ranked with calcium oxide as a dehydrating agent for alcohols.

THE SIOUX CITY WATER SUPPLY.

BY ALFRED N. COOK AND C. F. EBERLY.

A good water supply is one of the greatest boons man can possess. Notwithstanding this fact, it is the one thing above all others, almost, which is likely to receive the least attention. It is well known to those who have given the subject some study that the taste is no criterion by which to judge a water. So often have we known men to declare that a certain water was good because of its excellent taste, often due to chlorides, nitrates, etc., derived from sewage, or outhouses not far distant. So often men will provide their families with every comfort that modern applied science has made possible and yet unknowingly be using a contaminated water supply. This was recently well illustrated by a prosperous professional man of Sioux City who not long since built a new home in Morningside and furnished it with every modern convenience at a cost of several thousands of dollars. Instead of tapping the city water supply which was not far distant, he dug a well and within two or three rods of the well sank a large cesspool which receives the drain from the kitchen and water closet.

*Allen's Com. Org. Anal., Vol. I, page 165.

The experimental work described in the following pages was done by Mr. C. F. Eberly, except where otherwise stated. Leffman's Manual of Water Analysis was used as a guide in the work, with frequent references to the original literature, or abstracts of the same. The results are given in milligrams per liter, except in the analysis reported by Professor Pope. The analyses made by Prof. Floyd Davis were reported in grams per U. S. gallon, but have been converted into the milligram system. Duplicate analyses were made in every case and the average of these reported.

The Big Sioux river flows along the western boundary of Sioux City about four miles west of the most thickly populated part of the city. Along its eastern bank are located a few manufacturing plants and Riverside park. It receives practically no sewage from the city. It receives the back water from the Missouri during the months of May, June and July. This back water extends a number of miles up the river and at the park rises to the height of about eight feet above the ordinary level. At other times it has a good current.

The greater portion of the ice consumed in Sioux City is obtained from this river. The specimen for analysis was taken at Riverside park, November 28, 1901, when the river was at its normal height. The water was slightly turbid but it was not filtered before making the analysis.

Total solids	340.
Loss on ignition	79.
Nitrogen as free ammonia	0.126
Nitrogen as albuminoid ammonia	0.280
Nitrogen as nitrates	Trace
Nitrogen as nitrites	None
Chlorine	9.936
Oxygen consuming power	2.011

The Missouri river forms the southern boundary of the greater part of Sioux City. It has a very swift current which carries with it a large quantity of sediment, especially when the river is high during the summer months, which is said to be due to the melting of the snow in the upper portion of its basin. The Missouri is a source

of a considerable quantity of ice used in Sioux City. The specimen for analysis was taken at the combination bridge on the Iowa side, May 27, 1901. The specimen for the determination of the suspended matter was taken December 14, 1901. If it had been taken on the first date the suspended matter would, undoubtedly, have been considerably greater.

Suspended matter	136.
Total solids	326.
Loss on ignition	73.
Nitrogen as free ammonia	.020
Nitrogen as albuminoid ammonia	.074
Nitrogen as nitrates	4.000
Nitrogen as nitrites	Trace
Chlorine	15.5
Oxygen consuming power	4.15

The Floyd river flows south through the eastern portion of the most populated portion of Sioux City, by the packing houses, and empties into the Missouri river where it turns to the south. It receives a great deal of contamination from the starch plant above the city and several small manufacturing plants upon its banks, the sewage from a large part of the business district, and the filth from the Armour and the Cudahay packing houses and the Sioux City stock yards. The water during the summer becomes very foul, so much so, that it is a nuisance to that part of the city through which it flows.

From the Seventh Street bridge to its mouth, a distance of about one mile, it has a fall of about one inch. It empties at right angles into the Missouri, from which during several months of the year it receives the back water, which extends up the river to the distance of one and one-fourth miles to the Floyd Flour mill dam. At other times when the wind is in the south the surface filth is kept from flowing out. Under any conditions the current is not sufficient to carry out the filth. When the back water from the Missouri flows out, which occurs once a year, a partial cleansing takes place.

The city is preparing to straighten the channel of the Floyd so that it will empty into the Missouri toward down

stream instead of at right angles. On account of emptying farther down stream, the river will then have a fall of seven inches, instead of one, for the last mile. This, together with the friction of the waters of the Missouri, it is believed, will give considerable increase to the velocity of the current. It is planned also to put flood gates in the Floyd, by means of which the waters will be caused to rise to the height of five feet and then be released automatically. This will, no doubt, thoroughly wash out the Floyd and put it in good sanitary condition.

The Sterling Packing Company took two crops of ice from the Floyd during the winter of 1900-1901. The specimen for analysis was obtained at the Chambers street bridge, November 13, 1901.

Total solids	402.
Loss on ignition	90.
Nitrogen as free ammonia	1.816
Nitrogen as albuminoid ammonia	3.783
Nitrogen as nitrates	Trace
Nitrogen as nitrites	.125
Chlorine	67.845
Oxygen consuming power	5.782

The water was turbid, had a very strong odor, and its stench increased when kept in a closed flask a short time. When distilled it gave off the odor which accompanies the scalding of hogs. It had a greasy appearance and even felt greasy. The large amount of chlorine is probably due to brine. Albuminoid ammonia continued to come off as long as any water remained in the distilling flask.

The Half Moon Lake, so called because of its shape, is a detached portion of the Floyd river. It is located just east of the packing house district. It is fed by springs, surface water, and by the melting of the snow. It has no outlet, except when high, when the excess of water flows off through a culvert under the railway grade. The water is always turbid, abcut fifteen feet deep in the center, and there are two or three feet of fine mud in the bottom of the lake. Organic decomposition is taking place as is evidenced by the bubbles continually rising to the surface. The

specimen for the technical analysis was obtained February 15, 1901, and the specimen for the sanitary analysis was obtained October 2, 1901.

TECHNICAL ANALYSIS.

Calcium oxide (CaO)	83.9
Magnesium oxide (MgO)	27.2
Silica (SiO_2)	27.
Carbon Dioxide (CO_2)	98.7
Sulphur tri-xide (SO_3)	14.7
Alumnia (Al_2O_3)	7.2
Ferric Oxide (Fe_2O3)	.8

SANITARY ANALYSIS.

Total solids	226.
Loss on ignition	70.
Nitrogen as free ammonia	.101
Nitrogen as albuminoid ammonia	.320
Nitrogen as nitrates	1.000
Nitrogen as nitrites	None
Chlorine	13.775
Oxygen consuming power	10.192

Albuminoid ammonia continued to come off until the containing vessel broke.

From the above analysis we would not consider the water of the Half Moon a good potable water, yet a considerable portion of the ice used in Sioux City is taken from this lake. It is not probable that any of the filth from the Armour packing house seeps into the lake, as has popularly been suspected, since the surface of the lake is higher than the surface af the Floyd which is less than one-fourth mile away and the high railway grade between the packing house and the lake would prevent any surface water from flowing in.

The Well Water at 1609 Orleans Avenue, Morningside, is located on the low ground east of Longfellow schoolhouse. It is a dug well eighty-five feet deep. There are several water closets within a few rods, and several others have been located in the immediate locality during the past twelve years. The technical analysis was made in the month of March, and the sanitary analysis in May, 1901.

TECHNICAL ANALYSIS.

Calcium oxide (CaO)	103.1
Magnesium oxide (MgO)	32.3
Sodium oxide (Na_2O)	4.8
Carbon dioxide (CO_2)	212.2
Silica (SiO_2)	12.2
Sulphur trioxide (SO_3)	19.4
Alumina (Al_2O_3)	7.75
Ferric oxide (Fe_2O_3)	.45
Manganous oxide (MnO)	Trace

SANITARY ANALYSIS.

Total solids	388.
Loss on ignition	131.
Nitrogen as free ammonia	.034
Nitrogen as albuminoid ammonia	.030
Nitrogen as nitrates	8.100
Nitrogen as nitrites	None
Chlorine	4.000
Oxygen consuming power	.625

Considering the conditions which surround this well, the water is very much better than one would expect. The analysis shows that it comes within the prescribed limits of a safe potable water, indeed quite as good as the city water.

Mr. Culbertson's Well is located a few rods north of the preceding well and is surrounded with practically the same conditions. The results of the analysis are not quite so favorable, however. The analysis was made in the latter part of April, 1901.

Total solids	569.
Loss on ignition	203.
Nitrogen as free ammonia	.016
Nitrogen as albuminoid ammonia	.046
Nitrogen as nitrates	39.4
Nitrogen as nitrites	Trace
Chlorine	5.5
Oxygen consuming power	1.12

I. N. Stone's Well, Morningside, is situated on high ground and surrounded by a lawn. It is eighty feet deep and contains about two feet of water. When this analysis was made there was a water closet within thirty-five feet and a barn about one hundred feet distant. They have since

been removed. The water had a sparkling appearance and a slight odor. When allowed to stand in a closed vessel for some time it possessed a slight odor of urea. The analysis was made in September, 1901.

Total solids	461.
Loss on ignition	124.
Nitrogen as free ammonia	.066
Nitrogen as albuminoid ammonia	.027
Nitrogen as nitrates	6.666
Nitrogen as nitrites	.22
Chlorine	2.7
Oxygen consuming power	6.09

The amount of nitrites found would, alone, condemn its use as a potable water.

Armour & Company obtain the water for their large packing plant from two wells, 347 and 400 feet deep respectively. The analysis was made in the latter part of November, 1901.

Total solids	556.
Loss on ignition	148.
Nitrogen as free ammonia	.262
Nitrogen as albuminoid ammonia	.025
Nitrogen as nitrates	Trace
Nitrogen as nitrites	None
Chlorine	8.3
Oxygen consuming power	1.568

The Consumer's Ice Company obtain their water for manufacturing ice from a well 122 feet deep and which is said to pass through a stratum of rock into a gravel bed. It is first distilled and then frozen in cans by means of salt brine. The specimen was taken from a clear block of ice weighing 300 pounds. The analyses were made in the latter part of November, 1901. If the ice is manufactured entirely from the distilled water, we have no theory to account for the fact that both the free and albuminoid ammonia are higher in case of the ice water than from the well water from which the ice was manufactured. The presence of the chlorine may be explained by the carelessness of the operator in allowing brine to get into the water before being frozen.

ANALYSIS OF THE WATER.

Total solids	278.
Loss on ignition	48.
Nitrogen as free ammonia	.092
Nitrogen as albuminoid ammonia	.C47
Nitrogen as nitrates	None
Nitrogen as nitrites	None
Chlorine	37.85
Oxygen consuming power	1.47

ANALYSIS OF THE ICE WATER.

Total solids	34.
Loss on ignition	19.
Nitrogen as free ammonia	.194
Nitrogen as albuminoid ammonia	.170
Nitrogen as nitrates	Trace
Nitrogen as nitrites	None
Chlorine	3.86
Oxygen consuming power	1.32

The Artesian Well is located at 311 Bluff street, and is 2,011 feet deep. It was originally drilled by D. A. Magee & Company. It is now owned by Christerman & Company, who use the water in their mineral water plant. Two analyses are given below. The one by Juan H. Wright, M. D., an analytical chemist of St. Louis, Missouri, was made in May, 1883. The one by Prof. Thomas E. Pope of the Iowa Agricultural College was made in 1884. The reports of these two analyses have kindly been furnished by Mr. D. A. Magee. It will be observed that there is a marked difference between the two analyses. It may be said, however, that Mr. Pope's analysis is in fair accord with that made by J. B. Weems and reported as the "official analysis" in Vol. VI, page 225, of the Report of the Iowa Geological Survey. The results are given in U. S. grams per gallon.

ANALYSIS BY POPE.

Sodium chloride ($NaCl$)	4.328
Sodium sulphate (Na_2SO_4)	14.763
Potassium sulphate (K_2SO_4)	5.045
Calcium sulphate ($CaSo_4$)	44.248
Calcium bicarbonate ($CaCO_3, H_2CO_3$)	4.305
Magnesium bicarbonate ($MgCO_3, H_2CO_3$)	15.265
Iron bicarbonate ($FeCO_3, H_2CO_3$)	.484
Silica (SiO^2)	.175
Alumina (Al_2O_3)	Trace

ANALYSIS BY WRIGHT.

Carbonate of lime ($CaCO_3$)	6.654
Magnesium carbonate ($MgCO_3$)	5.527
Iron carbonate ($FeCo_3$)	3.797
Aluminum sulphate ($Al_2(SO_3)$)	22.073
Magnesium sulphate ($MgSO_4$)	10.037
Nickel sulphate ($NiSO_4$)	1.141
Calcium sulphate ($CaSO_4$)	6.839
Sodium sulphate (Na_2SO_4)	3.751
Potassium sulphate (K_2SO_4)	2.115
Iron sulphate ($FeSO_4$)	13.402
Sodium Phosphate (Na_2HPO_4)	1.667
Silica (SiO_2)	1.882
Organic matter	.864

The City Water Supply comes from 104 driven wells ninety feet deep. The source is beneath an impervious stratum of clay. The water is stored in a reservoir 150 feet in diameter, located on an eminence north of the city, from whence it is distributed to consumers. The reservoir is surrounded by an iron fence and carefully guarded. In the summer there is to be seen occasionally a green growth on the water which is so common to bodies of standing water in the summer months, but the tank is emptied and cleaned every three weeks. The specimen for Analysis I was taken from the hydrant at Morningside college, which is located six miles from the reservoir, in May, 1901. The specimen for Analysis II was taken at pumping station No. 1, in May. It will be observed that the results of the two analyses are practically the same. The specimen for the technical analysis was taken at Morningside college in February, 1901.

ANALYSIS I.

Total solids	415.
Loss on ignition	167.
Nitrogen as free ammonia	.022
Nitrogen as albuminoid ammonia	.0232
Nitrogen as nitrates	·12.4
Nitrogen as nitrites	Trace
Chlorine	8.9
Oxygen consuming power	.6

ANALYSIS II.

Total solids	406.
Loss on ignition	159.
Nitrogen as free ammonia	.024
Nitrogen as albuminoid ammonia	.061
Nitrogen as nitrates	9.1
Nitrogen as nitrites	Trace
Chlorine	8.2
Oxygen consuming power	.685

The following analysis was made by Prof. Floyd Davis, chemist of the Iowa State Board of Health in April, 1891. The specimen was obtained from pumping station No. 1.

Total solids	393.
Loss on ignition	61.2
Chlorine	4.634
Free ammonia	.021
Albuminoid ammonia	.024
Nitrogen as nitrates	.735
Nitrogen as nitrites	None

The following analysis of a specimen from pumping station No. 2 was also made by Dr. Floyd Davis at the same time as the specimen mentioned above. He states that "This sample of water contained a large amount of suspended matter in it and the analysis was made of the filtered water." The water from the station is now only occasionally used for the city supply. It will be observed that the results of the two analyses are practically the same.

Total solids	415.2
Loss on ignition	69.6
Chlorine	3.6
Free ammonia	.021
Albuminoid ammonia	.045
Nitrogen as nitrates	Trace
Nitrogen as nitrites	None

The two following technical analyses were made by Mr. Davis at the same time as the sanitary analyses:

PUMPING STATION No. 1.

Silica (SiO_2)	32.43
Sodium oxide (Na_2O)	14.53
Potasssium oxide (K_2O)	5.91
Sulphur trioxide (SO_3)	9.55

Phosphoric anhydride (P_2O_5)	Trace
Aluminia (Al_2O_3)	3.97
Ferric oxide (Fe_2O_3)	Trace
Calcium oxide (CaO)	120.05
Magnesium oxide (MgO)	47.96
Carbon dioxide (CO_2)	153.96

PUMPING STATION No. 2.

Sodium oxide (Na_2O)	15.94
Silica (SiO_2)	32.19
Potassium oxide (K_2O)	4.37
Sulphur trioxide (SO_3)	7.25
Phosphoric anhydride (P_2O_5	Trace
Alumina (Al_2O_3	3.805
Ferric oxide ($Fe\ O_3$)	Trace
Calcium oxide (CaO)	130.42
Magnesium oxide (MgO)	48.96
Carbon dioxide (CO_2)	170.55

The following technical analysis of the water, taken from the hydrant at Morningside college, was made in January 1901.

Silica (SiO_2)	14.4
Sodium oxide (Na_2O	27.5
Sulphur trioxide (SO^3)	12.5
Alumina (Al^2O_3)	1.00
Ferrric oxide (Fe_2O_3)	.30
Manganous oxide (MnO)	Trace
Calcium oxide (CaO)	120.6
Magnesium oxide (MgO)	53.9
Carbon dioxide (CO_2)	236.2

A comparison of the results of the technical analyses given above will reveal the fact that the mineral character of the water has not greatly changed in ten years. Ferric oxide was found in the last analysis, but this may have come from the iron pipes, through which the water flows for several miles. There is an increase in the amount of sodium, silica, alumina, and magnesium but the general character of the water remains practically the same.

A comparison of the sanitary analyses shows that there has been some change in ten years. The free and albuminoid ammonia remain about the same, but the chlorides have increased over two and one-half fold, the nitrates fifteen

fold, and the loss on ignition is very much greater. A comparison of the water supplies of several cities shows that the Sioux City supply is better than those of Brooklyn, Boston, and Cincinnati and quite as good as those of several other cities.

IGNEOUS ROCKS OF THE CENTRAL CAUCASUS, AND THE WORK OF LOEWINSON-LESSING.

BY CHARLES R. KEYES.

(Abstract.)

In view of the widespread interest that the subject of the differentiation of rock-magmas is exciting among geologists generally I am led at this time to call your attention to one of the most recent, and at the same time one of the most important contributions which has yet been made. My notice will be brief, and will consist chiefly of an exhibition of specimens of many of the most notable rock-types. An explanation of some of the most significant features will be given. Photographs of some of the most characteristic rock-masses as they appear in the field will be shown. These were obtained during a recent trip through the Caucasus region in company with the Russian investigator himself, guiding one of the excursions of the Seventh International Geological Congress.

Although the great work of the Russian petrographer, F. Loewinson-Lessing, on the Eruptive Rocks of the Central Caucasus, was issued more than two years ago, the views advanced are only beginning to get into form accessible to the majority of English students. The general interest lies in the discussions of the subjects of rock-classification and the differentiation of rock magmas.

The classification proposed for the igneous rocks is chemical. It is based primarily upon the degree of acidity of the silicate minerals. Four great groups are thus

established: (1) The ultra-basic rocks, derived from a monosilicate magma; (2) basic rocks, which had a bisilicate magma; (3) neutral rocks, with a magma which was bisilicate or normal, and (4) acid rocks, in which the magma was polysilicate. These groups are subdivided into fourteen sub-groups and thirty-four families.

In order to find the proper systematic position of an eruptive rock from the fundamental viewpoint of the proposed classification, four factors are considered: (1) The relation of the oxygen in the silica and that in all the other oxides taken together, giving what is termed the coefficient of acidity; (2) the chemical composition, which gives for each type a distinct formula; (3) the relations between the two groups of oxides according to their molecular proportions, and (4) the relations of the soda and potash in the alkaline rocks. This consideration of the principles of classification leads to the proofs of the distinct phases of fundamental magmas.

Discussion of the differentiation of rock magmas has an unusual interest. The Russian author calls special attention to the principle of Soret, the action of super-saturated solutions, the effect of gravity, the principle of maximum work as proposed by Berthelot, and the reactions of mixed liquids, as operating in the separation of magmas.

Three distinct kinds of magmatic differentiation are recognized. They are: Static differentiation, taking place in the depths of the earth; differentiation by cooling during ascent to the surface; and crystalline differentiation. Specific gravity, pressure, and temperature are the chief factors governing the course of the static kind; while chemical affinities come into play in large measure only in crystalline separation.

The role of inclusions of foreign rocks, which has so long been such an unsatisfactory subject to petrographers, is explained on the idea that it is only that portion of the magma yet undifferentiated which affects the introduced rocks. After thorough assimilation of limestone for example, a separation of the modified magma takes place.

Mount Kasbee, Central Caucasus.

Mount Elbruz, Southern Russia; the highest point of Europe.

One part contains very little lime and the other nearly all of it. Rock formed from the first mentioned might be a granite, while from the second would come perhaps a gabbro.

EVIDENCES OF RECENT UPRISINGS OF THE SHORES OF THE BLACK SEA.

BY CHARLES R. KEYES.

(Abstract.)

The photographs which I have to show you are to illustrate some remarkably clear examples of very recent changes in elevation of the earth's crust. Most of the pictures were taken in the neighborhood of Sudak, in the Crimea. The southern coast of this peninsula is very rugged. It rises abruptly out of the water to a height of 3,000 to 5,000 feet. The waves are constantly eating back so that in many places the coast land is almost a sheer precipice hundreds of feet high.

But the point to which attention is particularly called is the sharply cut benches and narrow beaches which occur at various levels, from fifty to four hundred feet and more above the present sea-level. These show, in an exceptionally fine manner, the action of the waves when the land stood at a much lower level than now.

Farther to the westward near Cape Violence, not far from Sebastopol, the country is less rugged than at Sudak; and often broad plains are found stretching down to the sea-level. These plains gradually rise to the eastward and where cut by the waves display sections that show a number of unconformities between the various terranes. Some of these unconformity-planes appear to extend inland and to become continuous with well-marked peneplains now being rapidly dissected.

As further evidence of this rapid change in the land position with reference to the sea-level in very recent times, Prof. G. F. Wright, who has lately returned from the same region, informs me that during his trip he found on the south shore of the Euxine, near Trebizone, especially, gravel beach-deposits at an elevation of nearly 700 feet.

Now the great interest in these observations lies in the fact that the region occupied by the Black sea is a part of that wonderful belt of depressed crust which bisects the Eurasian continent and which extends the whole length of the Mediterranean sea, through the Black and Caspian seas, the Sea of Aral, to beyond Lake Balkash. The surface of the Caspian is nearly 100 feet below general sea-level. The country on the north side of the Caucasus, between this body of water and the Black sea, is scarcely 200 feet above sea-level at its highest point.

Altogether, this region is perhaps the best we know of for studying through the means of exact data, problems of differential elevation of the earth's crust.

Elevated terraces on the Black Sea; Sudak, Crimea.

A DEVONIAN HIATUS IN THE CONTINENTAL INTERIOR—ITS CHARACTER AND DEPOSITIONAL EQUIVALENTS.

BY CHARLES R. KEYES.

In Iowa, with our nearly 500 feet of Devonian sediments, we are not apt to think very much about a possibility of the lack of this great system soon after the boundaries of our state are passed. Yet the possibility is an actuality. In west-central Missouri it has been lately found that no rocks of Devonian age are represented. The lower Carboniferous strata rests directly upon Ordovician dolomites.

The general section east of Clinton, Missouri, on Grand river, a tributary of the Osage, is as follows:

	FEET.
Henrietta limestones	60
Cherokee shales (Des Moines series)	100
Augusta limestone	175
Chouteau limestone (Mississippian series)	15
Ordovician dolomite (exposed)	20

This gap in sedimentation in west-central Missouri includes, as is shown, more than the Devonian alone. The whole of the Silurian is absent. But only the Devonian portion is considered at this time for the reason that important correlations have been recently made, and these bear directly upon the nature of the hiatus.

Southward, in southwest Missouri, the Devonian strata again put in their appearance. In northern Arkansas Williams has also lately demonstrated that both Devonian and Silurian sediments were laid down in this part of the region. On the east side of the Ozark plateau, along the Mississippi river, both Silurian and Devonian sequences are unbroken.

It has been thus assumed that the Devonian beds form one of the originally deposited concentric zones around the older rock-mass of the Ozark dome. On this account chiefly it has been urged that the Devonian sediments were laid down around what is termed the Ozark Isle. The necessary inference is that during Devonian times subaerial erosion took place over all the present Ozark region.

Attention to a few facts quickly dispels this hypothesis. The Devonian sediments themselves show nowhere a coarse littoral character. The "concentric ring" is not an unbroken one; it is sundered on the southeast and on the northwest parts of the great dome. Devonian deposits, highly fossiliferous, occur on the highest portions of the uplift; showing unmistakably that, in the absence of other evidence to the contrary, they once extended unbroken over the entire uplift. It is clearly manifest from geographic inquiry that the present Ozark dome is a very recent uprising - probably post-Tertiary.

In the face of these facts the hiatus in central Missouri has a special significance. It points at once to the suggestion that the area in which there was no Devonian deposition was not a sub-circular one, coincident with the Ozark dome of today, but a narrow ridge-like elevation. The structure of the Ordovician beds of the region also indicates that this is the true explanation. Ten years ago I called attention to the location of this old ridge. Today its importance appears much greater than was at that time supposed.

Now, we have through the Mississippi valley, at least west of the great river, two horizons which are exceptionally clearly defined. One is the top of the Silurian. The other is the base of the Chouteau-Burlington limestones. Between these two stratigraphic horizons the beds are here assumed to be Devonian in age. The formations represented in typical localities are as follows:

GENERAL DEVONIAN SECTION OF IOWA.

	FEET.
Lime Creek shales	100
Cedar Valley limestone	150
Wapsipinicon limestone	150
Independence shales	[illegible]

GENERAL NORTH MISSOURI SUCCESSION.

	FEET.
Hannibal shales	75
Louisiana limestone	50
Grassy Creek shales	30
Callaway limestone	80

SECTION OF SOUTHWEST MISSOURI.

	FEET.
Hannibal shales	90
Louisiana limestone	10
Phelps sandstone	15
Sac limestone	15
King limestone	15
Eureka shales	10

NORTH ARKANSAS SECTION.

	FEET.
St. Joe marble (Carboniferous)	50
Eureka shales (typical)	80
Sylamore sandstone	40
Eureka shales (in part) and Green shales	50
St. Clair limestone (Silurian)	180

It will be noted that two of the formations which were included in the original Kinderhook division of the Lower Carboniferous, are here classified with the Devonian. On account of lying on the border of the Devonian and Carboniferous the original Kinderhook has a special interest at this time. In the last half century there has been so much controversy in regard to the age and distribution of the Kinderhook that we must now look into original meanings before attempting to arrive at conclusive interpretations.

At the outset three separate and distinct lines of consideration arise. They have to do, first, with the stratigraphy, second with the faunal features, and, third, with the geological age according to the most approved methods of determination. Each of these phases has an individuality of its own and requires a perfect independence of treatment. Usually no distinction is made; and therein is the source of much of the confusion which has arisen regarding the real nature and relations of the Kinderhook.

A summary of the history of the opinion is not without interest. The first important notice of the beds in question is that of Owen. As one passes in review the published data relating to the beds which have given rise to the Kinderhook controversy he cannot help looking upon many of

the points in a very different light from that in which they were originally presented. Standing now after a lapse of sixty years, one cannot but marvel at the wonderful discernment with which the first efforts to differentiate the Carboniferous formations were made. Time has not dimmed the work of that indefatigable pioneer in American geology, David Dale Owen, in his discriminations concerning the Carboniferous limestones of the Mississippi valley.

The arrangement of the geological formations as proposed by Owen rests primarily upon lithologic grounds; but fossils receive their full consideration. So far as it goes, Owen's scheme is essentially the plan now accepted. New titles have been proposed, but the actual divisional lines remain unaltered. To the shales underlying the Encrinital (Burlington) limestone at Burlington and Hannibal Owen gave the name Argillo-calcareous group. Although the nether limit was not specific the group is known to be practically co-extensive with what was later termed the Hannibal formation.

When fresh from the rich paleontologic fields of New York, where a standard Paleozoic section for America had been recently established, James Hall was easily led to discern in the rocks of the Mississippi valley the faunal horizons which he knew so well in his native state. In the Argillo-calcareous group of Burlington and Hannibal he fancied that he recognized the Chemung of the East. He had already traced the Devonian formation westward to the Mississippi river.

The determination of the Devonian age of the shales at the base of the section at Burlington and at Hannibal did not rest upon observations at these points alone. There was a correlation of these beds with lithologically similar beds farther to the northward at Muscatine and in northern Iowa where there was an obvious association with undoubted Devonian limestones. Singularly enough, after forty years of uncertainty Hall's correlation and assignment of Devonian age to these strata, are again beginning to be demonstrated to be correct. At no time during all the

prolix discussions did Hall abandon his early views on the Devonian age of these shales which have so long been called the median member of the Kinderhook.

G. C. Swallow, the first state geologist of Missouri, with the aid of the paleontologists Meek and Shumard, recognized in his state, immediately beneath the great Encrinital limestone a three-fold division which he referred to the Chemung section of the Devonian. This author introduced a new member into the succession by defining the Chouteau limestone. In central Missouri this limestone attains a thickness of 100 feet. No one would suspect from examination along the Mississippi river that such an important formation existed at the base of the Burlington limestone. Hence, it is not strange that the geologists who had only seen the river sections gave the dozen feet of earthy limestone at the bottom of the Burlington so little consideration.

Meek found the Chouteau limestone in the original locality to contain many forms of fossils. Their great resemblance to those in the limestone above had a tendency from the first to somewhat shake his faith in the Devonian age of the beds. In his later report, on Saline county, Missouri, the next year (though not published until seven years afterwards) he was fully convinced that the Chouteau limestone should be associated with the Carboniferous rather than the Devonian. It is a noteworthy fact in this connection that, in central Missouri, the lower two members of Swallow's Chemung appear to be wanting.

Meek and Worthen's Kinderhook formation has a singular nominal history. The proposal of the term Kinderhook as a geological title was unfortunately shrouded by personal animosities. When, in 1860, Worthen and Meek began their labors on the geological survey of Illinois both had recently become very bitter against Hall, and could scarcely restrain themselves in attempts to overthrow some of the latter's work. Worthen had fancied an unpardonable grievance because, while connected with the Iowa survey under Hall, the latter had verified some of the former's

observations, but had used names of his own instead of those previously suggested in manuscript. Meek had just left Hall's laboratory in Albany as the result of a quarrel about the proper draughting of some of the fossils for the latter's New York report. Intense rivalry had also now arisen between Hall and Meek and Worthen as to who should first describe the new fossils which were, about 1860, being discovered in the rich fields along the Mississippi river in Illinois and the neighboring states.

Thus in considering the beginnings of the Kinderhook controversy there is a certain element of biased judgment which has to be eliminated. Many misstatements of fact, many misquotations of contemporaneous opinion, and many misinterpretations of published work appeared in the first paper by Meek and Worthen on the Kinderhook. No doubt the intention of the Illinois authors was to present the facts as they thought they really were, but with glasses somewhat colored, enthusiasm born of new discoveries, and jealous rivalry, they evidenced a haste that was not customary with these usually very careful workers.

But aside from the shortcomings just mentioned there appears to be far more important factors that were overlooked in the proposal of the group Kinderhook and the assigning of it all to the Carboniferous. Meek and Worthen's conclusions were far too sweeping. The triple membered Chemung of Swallow had not all been examined by the authors mentioned. To them practically only the upper member had yielded fossils. The Vermicular (Hannibal) shales and the Lithographic (Louisiana) limestone was admittedly barren of organic forms, except half a dozen or more species and almost as few individuals, which had been found at the very base of the formation.

Meek had already studied in Missouri only the fossils from the typical Chouteau; and had come to regard them as Carboniferous forms. At Burlington fossils had been collected from the Kinderhook only near the base of the Burlington limestone. At the type locality of Kinderhook

the fossils are found chiefly in the upper layers of the formation. Meek and Worthen's collections are now known to have been all made from layers within a few feet of the bottom of the Burlington limestone.

The fauna of Meek and Worthen's Kinderhook group is, therefore, not the fauna of the whole of the three-fold terrane which has long been known to geologists as the Kinderhook, but it is the fauna only of the upper limestone member—the Chouteau limestone. By them the fossils of the lower two members of their Kinderhook were not considered in the least degree. To them, the lower faunas were unknown. They delimited one geological sequence lithologically. For the whole they defined faunally only a very small part of the same sequence. They assigned a definite geological age to the whole; when they were actually justified only in ascribing an age to a single member. The Kinderhook fauna as we today know it is in reality only the fauna of the Chouteau limestone. We know now that other and very different faunas occur in the shales and limestones immediately underneath.

This brings us to the question as to what is the Chouteau stage. The biological geologists are inclined to apply the term Chouteau to the earliest of the three categories into which they subdivide the Eo-Carboniferous of the Mississippi valley. The title thus refers to the Kinderhook terrane of Meek and Worthen. Before the application of the term in this sense the name had already been formally given to the upper member of the Kinderhook. Broadhead's subsequent extension of the title making it synonymous with Kinderhook does not appear to render it in any way valid.

Chouteau, if it is to be retained as a faunal term in geology, can only be made to apply to the stage of the Chouteau limestone. In this sense it satisfies all the requirements of dual classification in geology. Moreover, it may refer to a fauna that is a compact unit. It applies to a fauna which is believed to be Carboniferous. It eliminates the incongruous elements which are not Carboniferous in

character. Referring to terranes, the name would apply to the lowermost member of the Mississippian series.

The fauna which is generally thought to be the fauna from the original Chouteau limestone is at best a fancied medley of shadowy definition. Practically no detailed work has yet been published. Careful determination of the exact horizons of the various forms has not even been attempted. Of the species described from the original Chouteau of central Missouri many are now known to be from formations other than the terrane under consideration. It is small wonder, therefore, that the Chouteau or Kinderhook fauna as we have so long known it is apparently ill-defined, anomalous and puzzling. In the critical study of the lowest Carboniferous faunas of the Mississippi valley there is need, before all else, of exact determination of the various organic forms that occur in the original Chouteau limestone of central Missouri. It is only with this type fauna that the faunas of the Kinderhook from other localities and other horizons can be compared with profit. Until the fossils from the original Chouteau are carefully collected and studied anew in their entirety the "Choteau fauna" must be regarded as a quantity unknown.

PAROXYMETAMETHYLACETOPHENONE AND SOME OF ITS DERIVATIVES.

BY J. G. GOODWIN.

Work leading toward the preparation of this and if possible toward one of its isomers, was commenced with work on phenol. First the phenyl acetate was made as follows: forty-one grams of phenol were taken in a distilling flask, and to this were added gradually, through a reflux condenser (in hood) twenty-eight to thirty grams (excess) of acetyl chloride. The flask was heated in a water-bath until the HCl ceased to come off. The contents of the flask were then washed with a dilute solution of sodium hydroxide, brought into a separating funnel with water, and the oil separated, dried over calcium chloride and distilled. B. p. = 195°. Yield forty grams. The phenyl acetate then made was converted into p. acetylphenol as follows: forty grams of the acetate were treated with twenty-eight grams of acetyl chloride and fifty grams of dry, powdered aluminum chloride added, with reflux condenser. Ligroin was added for a solvent, and the whole heated on a water-bath for one hour. The contents of the flask were poured into water, and the oil dried and distilled in fractions as high as 200°. The part below 132° was counted ligroin. The part undistilled was small and caused bumping on further heating. The fraction 132°—200° was treated with strong sodium hydroxide in a flask to hydralize it, the unhydrallized portion being kept for subsequent treatment. The alkaline liquid was acidulated with dilute sulphuric acid, and the oil separating out extracted twice with ether. The portion above 200° was treated in a similar

manner. When the hydrolysis would proceed no further, the ether was distilled off over a waterbath, and set aside for evaporation. The portion from the 132°—200° fraction crystallized in long needles, that of higher boiling point remained an oil even at -17°. The crystals melted at 107° and were soluble in warm water and in the usual organic solvents.

The product is p. acetylphenol. This shows that the first acetyl group going on was split off and the hydroxyl restored by hydrolysis, the acetyl group para to it remaining. In putting on the second group the halogen acid was split off from the acetyl group. This cleavage was next tried with anhydrous zinc chloride as an agent, instead of aluminum chloride. This is said* to be of advantage, especially where organic radicals are to be introduced into the nucleus of phenol, amines, and acids. It is specially used, therefore, for making ketone acids, oxy-ketones, etc., whereby naturally the acid group reacts also with the amido or hydroxyl group, unless, as is better, this has been done first. The ordinary rules for position hold.

To apply this method three grams of phenol are taken in a large test-tube and to it 4.5 grams of benzoyl chloride added slowly, the whole heated in a water-bath to drive of excess of HCl. Again the same quantity of benzoyl chloride is added and a small quantity of freshly prepared anhydrous zinc chloride added until no further action is caused by it. While this is being added the tube is kept at 180 by means of an oil-bath. Crystals appear. The mass is brought into alcohol, heated to dissolve, filtered, cooled slowly, when crystals form and are freed from the mother liquor by means of a filter pump. They are washed with a small quantity of cold alcohol and warmed to drive of the alcohol. The crystals are in the form of leaves and are pressed on a porous plate to dry, and the melting point found to be 111°. The product is p. oxybenzophenonbenzoate.

Yield 2.2 grams.

*Elbs. Vol. II. p. 177

It may be in order here to speak of some of the different methods that have been used for forming these compounds. We find, for example, that o. oxyacetophenone was made by Y. Tahara from methyl salicylate through o. methoxybenzoylaceticester and o. methoxyacetophenone.* The last step, that of splitting off the methyl group, was accomplished by digesting for six hours the o. methoxyacetophenone with concentrated HCl at 150° in a sealed tube. Methyl chloride was evolved and also a brown oil which was extracted from its ethereal solution by means of sodium hydroxide and subsequent acidification, extracting with ether and evaporating, when the o. oxyacetophenone appeared in the form of a brown oil which was purified by distillation and crystallization. The sodium salt of this compound has the form of colorless leaves. The yield is small. The acetyl derivative was made by the action of acetyl chloride upon the sodium salt.

P. Freidlander and J.Neudorfer prepared the o. oxyacetophenone from o. nitrophenylpropiolic acid, converting this into nitro-phenyl acetylene, amidophenyl acetylene, and finally amidoacetophenone. This last named is diazotized to o. oxyacetophenone. The yield is better than that of Tahara. For the acetyl compound these experimenters heated the oxyacetophenone with acetic anhydride and sodium acetate to 150°. The acetyl compound crystallized out of alcohol in hexagonical plates. M. p. 89°.

Nencki and Stoeber studied the action of acetyl chloride on bezene and mono-basic phenols in the presence of ferric chloride.† Acetophenone was prepared. Yield not stated. P. oxyacetophenone was prepared from acetyl chloride and phenol, melting point 108°. 150 g. of phenol gave 30 g. of ketone. These men found also that the isomeric cresols acted like the phenols. From o. cresol, p. oxym. methylacetophenone was prepared, m.p. 104°. Also p. oxy o. methylacetophenone from m. cresol, m. p. 126°. Benzoyl chloride yielded no oxybenzoylphenone but only cresol benzoate. The method was to take molecular

*Berichte 25, pp. 1806-1810.
†Berichte, 8., p. 1768.

equivalents of the cresol and acetyl chloride, or a slight excess of the latter, and add anhydrous sublimed ferric chloride in quantities equal to the chloride. After the action the dark, syrup-like liquid is poured into water and the insoluble residue distilled with steam. The ketone passes over as an oil and solidifies. It is recrystallized from dilute alcohol. The solvent used in the first of these operations is carbon disulphide. The product out of o. cresol is colored brown by ferric chloride. We shall speak of this test again.

Nearly all these methods were tried in the laboratory. The method of Verly with large quantities of the phenol, aluminum chloride, low temperature and vacuum did not give a good yield of anything except the ester instead of the oxyketone. This was tried with phenyl benzoate and benzoyl chloride. The method was also tried with acetyl chloride and phenyl acetate, but the esters remained practically unchanged.

I next tried p. acetyl phenyl acetate, from phenyl acetate and acetyl chloride by means of zinc chloride and heat to 100° in oil bath. The temperature was kept at 100° as long as HCl was evolved. The yield was very small.

The phenyl acetate for these latter reactions was made as follows: To 60 g. of phenol 30 g. of powdered anhydrous sodium acetate was added in a flask and shaken, then 85 g. of acetic anhydride added gradually through a reflux air-condenser. The temperature of the oil bath was gradually raised to 150° and kept up until the liquid ceased to appear in the condenser. After cooling, water was added and the oil washed in a separating funnel, dried over calcium chloride and distilled at 195°; the yield was 69 g., or 63 per cent of the theory.

Repeated trials of zinc chloride and aluminum chloride failed to give any satisfactory product. Resort was then had to anhydrous ferric chloride. 5 g. of phenol dissolved in 5 g. carbon disulphide were taken in a small flask and 6 g. of acetyl chloride added. To them, by means of a rubber

tube to exclude moisture, anhydrous ferric chloride was slowly added—7 g. The flask was kept cool with a water-bath. The contents were poured out into water, the oil distilled with steam to drive off the carbon disulphide and phenol, the residue filtered hot. Yield 1.3 g. of p. oxyacetophenone. This method was then tried with p. cresol but even after repeated trials refused absolutely to work. Out of o. cresol, p. oxy m. methylacetophenone was prepared. Carbon disulphide was used for a solvent, with ferric chloride. The yield was 14.8 per cent. of the theory. The flask was kept cool to avoid loss of the solvent. The product was poured out on snow, so that the heat of reaction would not decompose it, and the oil distilled with steam, and purified as above, by crystallization. M. p. 104°.

It appears from the foregoing paragraphs that the place para to the hydroxyl group must be free in order that the cleavage and condensation may take place. Then the fact is, that the acetyl chloride acts on the para hydrogen, even when the hydroxyl group has not been changed or replaced, giving the oxyketone without any hydrolysis.

It appeared that the yield might be larger if the temperature were higher than that which the German experimenters had used—the boiling point of carbon disulphide. A higher temperature then was made possible by means of carbon tetrachloride as a solvent, which was used at 65°. The first trial gave a yield of 25 per cent. and this was subsequently raised to 28 per cent, while the best method that had been used by these Germans, Nencki and Stoeber, who used carbon disulphide and low temperature, gave a yield of 14.8 per cent. Repeated experiments showed that the temperature of 65° gave the largest product. A higher temperature gave more tar; at a lower temperature the reaction did not take place to any practical extent.

After a considerable quantity of this product, the p. oxy m. methylacetophenone had been prepared, I studied to find whether the product described by these chemists, Nencki and Stoeber, was pure. For this purpose the prod-

uct was purified by twice recrystallizing from hot water, when the crystals, heretofore slightly brownish in color were quite colorless. The test given by the former makers was a brown coloration with the ferric chloride solution. While the crude product of first crystallization gave a strong brown coloration with ferric chloride and red with sodium hydroxide (a very delicate test) the pure crystals gave no coloration at all. Further, the melting point was given as 104°. This was the melting point of the crude crystals, but the purified product showed a melting point of 106°. The crystals gathered on the surface of the liquid and on the bottom in long needles grouped about a nucleus on either side of the dish, at the bottom.

It then remained to determine the solubility, taste, etc. of the compound, no record of which was given in the account.

Since the crystals go to an oil when heated in water to 78°, the solubility was determined at two points below this temperature. At 22° the solubility was found to be 0.035 per cent. At 70° it was found to be 2.76 per cent.

The crystals gave no immediate taste even when powdered and placed on the tongue, but after about twenty seconds gave a strong, peppery taste.

Derivatives of p. oxy m. methylacetophenone. (New.)

Methyl ester.—The quantities taken were in the proportion of one gram molecule of the ketone, one of sodium hydroxide, one of methyl iodide and enough alcohol to dissolve the whole. The mixture was heated to boiling in a flask till the alkaline reaction disappeared. Most of the alcohol was then evaporated off and the residue poured into water. The product appeared as an oil which was extracted with ether, washed with very dilute sodium hydroxide, separated, dried over calcium carbonate and the ether filtered off in vacuo. The remaining oil was distilled under reduced pressure, in a stream of carbon dioxide. It boils at 230°, gives a colorless oil without much odor. It solidifies in a freezing mixture and remains a white, crystal line solid at room temperature, but melts at the tempera-

ture of the hand. The melting point was found to be 25°. P. oxy m. methylacetophenonemethylester. 6.47 g. of ketone gave 3.82 g. of the ester.

P. oxy m. methylacetophenonethylester. This was prepared in a manner similar to that of the methyl ester. The product however appeared as a white solid after distillation. It was purified as before, and dried on a porous plate. The yield was better, being 77.6 per cent of the theory. This compound is redistilled at 220°-230° under 74 mm. pressure. M. p. 34.5°.

The manufacture of the cetyl ester was attempted in the same manner that the methyl and ethyl esters had been made, but no product could be obtained which would solidify, and it had to be abandoned.

The experimental work ended here owing to lack of time.

ON THE OCCURRENCE OF RHIZOPODS IN THE PELLA BEDS IN IOWA.

BY J. A. UDDEN.

In Jefferson county the Pella beds of the Saint Louis formation have a thickness of about twenty feet. They consist of heavy ledges of calcareous limestones, interbedded with seams of marly shales, the latter being best developed in the upper part of the section. The several seams and ledges appear quite persistent and some have been identified at different points a few miles apart. They have evidently been laid down at some considerable distance from the shore. Occasionally there are ledges of limestone which are very fine-grained, almost lithographic in texture. Here as elsewhere in the south part of the state, the fauna of the formation is meager in species but quite prolific in individuals. *Pugnax ottumwa*, *Spirifer keokuk*, *Zaphrentis pallaensis*, *Anisotrypa fistulosa*, and stems of crinoids appear everywhere, especially in the marls. This has long been known.

A closer examination of these rocks shows that some rhizopods also are almost invariably present. By crushing, washing and sifting, these may be found in the marls and sometimes also in the limestone. The most common form has been identified by Schuchert as *Endothyra baileyi* Hall, which is known from Indiana and Illinois. But there are at least two or three other forms not yet identified. Associated with these are two ostracods: *Cytherellina glandulosa* and *Leperditia carbonaria*, and also some minute spines and plates of an Archæocidaris [very rare]. The presence of the rhizopods corroborates the view that the Pella beds were laid down some distance out in the open sea.

PLEUROPTYX IN THE IOWA COAL MEASURES.

BY J. A. UDDEN.

At a horizon of some hundred feet above the base of the Coal Measures in Fairfield township in Jefferson county is a seam of a concretionary limestone varying from two to five feet in thickness. It crops out on the hillside in a creek that follows the south side of the abandoned embankment of the Chicago, Burlington & Quincy railroad, where this leaves the new line, about a mile and a half west of the city of Fairfield. The ledge has been quarried in several places close to the line of the old road, where some pits are still seen. On this limestone lies a black, fissile bituminons shale, lumps of which are seen in the old pits. Last summer the writer found in one of these lumps a bone which he thought might be a phalanx of some early batrachian. This was submitted to Prof. C. R. Eastman of the Museum of Comparative Zoology, who identified it as belonging to *Pleuroptyx clavatus* Cope, discovered in the Coal Measures of Ohio. In the lump of shale which contained this bone some small enamelled rhomboidal scales and a few small conical teeth were also observed, and associated with these were some slender and polished bony spines and impressions of numerous small ostracods. The abundance of vertebrate remains was confined to a single lump of the shale, but it suggests that the locality might deserve a more thorough exploration.

THE UNIVERSITY OF MONTANA BIOLOGICAL STATION.

BY MAURICE RICKER.

Noticeable among recent movements tending to promote the interests of biological science is the development of the inland biological station. Any arrangement whereby students and teachers may work under proper guidance out of doors, in nature's own laboratory, should be encouraged. Our own state made a beginning last summer at Lake Okoboji. I sincerely hope it may become permanent and that many teachers in Iowa will avail themselves of the opportunity to combine a pleasurable outing with profitable field and laboratory work in Natural Science.

Indiana, at Winona lake, and Illinois at Havana, have opened permanent stations and drawn many earnest students. To be entirely successful the location must be such as to provide a variety of plant and animal life, but hardly less important is it that the place chosen have many of the attractions of a summer resort. It must furnish reasonable accommodations, be easy of access, and be favored with pleasant and healthy summer weather. All these requirements can hardly be fully met.

It is my purpose to give a brief description of the Montana Biological Station because it seems to me to be, in every way, the ideal.

The Flathead lake, in Northwestern Montana, is the largest body of fresh water west of the great lakes. It lies between the Mission and Cabinet ranges of the Rocky mountains. Its elevation is 2,800 feet. It is nearly thirty-five miles long and from eight to fifteen wide. It is drained by the Peud d' Oreille river which has rapidly cut

its canyon through the moraine, lowering what was formerly a much larger lake to its present level.

The main feeder of the lake is the Flathead river which now is a tortuous, sluggish stream through the ancient lake bed for seventy-five miles. It is from 300 to 600 feet in width and from twenty to seventy-five in depth. The last few miles have formed a typical delta, filled with swamps and ancient river beds.

The Big Fork or Swan river is the only other large stream emptying into the lake. It is the very opposite in character, coming plunging out of the mountains with a fall of over 100 feet to the last mile into a rocky bay. This forms a splendid harbor about four miles from the mouth of the Flathead river. On the bank, overlooking this harbor stands the laboratory building in a beautiful little park, leased to the state.

The boats and launch give access to the lake, the delta, and lake shores. I need not explain to this body what this means to the naturalist. The mountains, forests, and meadows back of the lake, with occasional marshes and ponds give a wonderful variety to the plant and animal life. Swan lake, six miles east by road, is twelve miles long by a few hundred yards wide. It is a drained river valley with mountains on either side. Rost lake about eight miles by road north is a much different body of water, being the shallow remnant of a much larger lake formerly occupying the valley. Echo lake two miles further is probably the ancient bed of a river. It has no visible outlet. It stood for some years at a much lower level. Trees and vegetation show that its level was suddenly raised about fifteen feet five years ago. This sudden change in environment seems to have been quickly responded to and it offers a rich field for biological investigation.

From the camp on Echo lake an expedition up the Blackfeet trail gives easy access to the pass, permanent snow field, an alpine flora and some of the most magnificent mountain scenery in the world. This one day is worth

the cost of the summer, is the unanimous opinion of all visiting students. Out of a party of thirty last season all but seven or eight reached the summit with ease.

If I have given you any conception of the region in this brief description I need not enlarge upon the character and variety of the plant and animal life. You will not be surprised to know that Dr. McDougal gathered 500 species of plants in thirty days, a total of over 900 in ten weeks in the field.

The laboratory building will accommodate about twenty students. It has a small store room and a convenient dark room. The work tables are well lighted and conveniently arranged.

The equipment is ample and of the best. All needed instruments, glassware, re-agents and preservatives are furnished.

The grounds are commodious and most of the students live in tents, some camping out in regulation style and others taking their meals at a nearby ranch which is a really good summer hotel. Those who prefer can have rooms as well as board as about twenty can be so accommodated. The rates are very reasonable. A general store and postoffice with daily mails will bring the station in closer touch with civilization this year.

The weather during July and August is delightful. There are no rains to hinder work, the temperature is just right day and night, the air is dry and the elevation not noticeable. Our thermostat registered between 70° and 80° for a maximum and from 46° to 55° for a minimum during the two months. Every evening was spent around the camp fire and the night between woolen blankets. I understand that those of you who spent the summer in the Mississippi valley were able to economize on camp fires and saved a good deal of wear and tear on sleeping bags.

Fishing, bathing, boating, and other sports furnish amusement for those who wish to combine work with recreation.

No tuition fees are charged. The expense of getting there is not so great as might be expected, owing to reduced rates to western points. The station is reached over the Burlington and Northern Pacific by stage from Selish to Polson on the lower end of the lake and thence by steamer tri-weekly, or over the Great Northern to Kalispell, by stage four miles to Dlemersville on the Flathead river and thence by steamer.

The station work has so far been eminently successful, due very largely to the untiring energy of the director, Prof. M. J. Elrod. I believe he has started what will finally become the most famous fresh water station in this country.

A LARGE RED HYDRA.

BY MAURICE RICKER.

During the summer session of the University of Montana Biological Station, we found what is believed to be a new hydra. It was taken in large numbers from Echo lake, Flathead county, Montana. It has never been found in any of the other numerous streams or lakes in this vicinity, and so far as is known no other hydra has ever been collected in the state.

The following are some of its most noticeable characteristics: The animals are conspicuous on account of their bright coral red color and large size. In fact, one can recognize them as hydra while standing on logs. A fair sample of the larger ones measured, when feeding, five-eighths inch from the mouth to the proximal end. None of the tentacles of this hydra were less than two and one-half inches long, measured from the mouth to the end, and the longest was two and eleven-sixteenths inches, making a total length from tip to tip of three and five-sixteenths inches.

When feeding, the tentacles are capable of unusual extension until they seem a mere thread bearing noticeably large nematocysts, like beads strung on a string.

The color is a deep bright coral red, most intense near the distal end and seems to be distributed in chloroplast like granules, as in H. viridis. It is apparently constant and may be due to symbiotic algae.

Since the waters of Echo lake contain large numbers of a reddish Daphnia, and, thinking the question of their effect on the color of the hydra would arise, a number of the latter were taken alive, and fed for five weeks upon colorless entomostraca, from Flathead lake, at the station laboratory. While they did not seem to thrive, no noticeable dimming of the color bodies was observed.

A careful study of the literature and of hydra from various localities will be made. Some eight species have been described but only two are at present allowed. This one seems to possess as much difference as is found between the H. fusca and H. viridis and careful study should either reduce them all to varieties or establish at least three species.

The striking color; the large size; the isolation of the animals from related forms; the apparent division of the body into a stalk and an enlarged gastric cavity, of about equal length; the removal of gonads and buds beyond this apparent division altogether seemed to make it worthy of notice. Histological examination will be made and it is believed the characters enumerated will prove constant and new.

SOME NEW DOUBLE BROMIDES AND THEIR DISSOCIATION IN AQUEOUS SOLUTION.

BY NICHOLAS KNIGHT.

The purpose of this investigation is to study the condition of double bromides in the presence of varying amounts of water. The substances herein described are well defined compounds, having a composition as definite and a crystalline form as characteristic as any group of chemical substances.

The question as to the way these substances break down in aqueous solution is an interesting one. Are they first decomposed into their constituent molecules, and then these molecules dissociated electrolytically by the water, as a mixture of the two substances would be, or do the molecules of the double salts exist as such in aqueous solution? No satisfactory answer has yet been received.

The application of the conductivity method to the problem of the existence of double salts in solution has been made by a number of investigators. The conductivity of solutions of the double salts, and also the conductivity of solutions of the constituent were determined. On comparing the sum of the conductivities of the constituents with the conductivity of the double salt at the same dilution, it is usually found that the conductivity of the double salt is very much less than the sum of the constituents in concentrated solution. Hence it is concluded that in such solutions the double salt is only partially broken down into the constituent substances. As the dilution increases the differences become smaller and finally disappear, or nearly so, indicating that in very dilute solutions the double salt entirely decomposes into its constituents.

A NEW DOUBLE BROMIDE OF SODIUM AND CADMIUM.

2 Na Br, 3 Cd Br_2, 6 H_2O.

The constituent bromides were brought together in proper proportion to form the double salt 2 Na Br, 3 Cd Br_2, 5 H_2O which is described in the literature. A beautifully crystallized salt separated out, and it was supposed to be the one described. The cadmium in the double salt was determined.

	FOUND I.	FOUND II.
Cd	30.0	29.6

The water was determined by drying a weighed portion of the salt to constant weight at 160°.

	FOUND I.	FOUND II.
H_2O	10.5	10.3

The bromine was then determined.

	FOUND I.	FOUND II.
Br	56.47	56.63

The cadmium, water and bromine correspond to a salt having the composition expressed by the formula:

2 Na Br, 3 Cd Br_2, 6 H_2O.

	CALCULATED.
Cd	29.8
H_2O	9.55
Br	56.59

The salt has the unusually high molecular weight of 1130.63.

A solution of the double salt was prepared and standardized by determining the amount of cadmium in a known volume of the solution. From this standardized solution, all the remaining dilutions were prepared thus: Solutions 2 to 6, and in some cases 2 to 7 were each prepared directly from the standardized solution by measuring off the desired volume of this solution into a measuring flask, and then diluting to the required volume. Solutions 7 to 11 were prepared from 6 directly in the same manner. Then No.

1 was taken as the mother solution, and the remaining olutions prepared in a similar manner from it. Dupliates of every solution were made and their conductivities etermined. All pipettes and measuring flasks used were arefully calibrated by the method of Morse and Blalock.* n measuring the conductivity of the solutions two cells rere used; one with the electrodes removed some distance rom one another for the more concentrated solutions, and he other with the plates close together for the more dilute olutions. In this way greater accuracy was possible.

The Ostwald modification of the Kohlrausch method was sed. The cells were carefully standardized with $\frac{N}{50}$ potassium chloride (Mu V=129.7 at 25°) at the beginning of each eres of measurements. The water used in the solutions ras prepared by the method of purifying devised by Jones nd MacKay†.

Solutions of the constituents were prepared and measred in the same way as the double salts.

In tables V is the volume of the solution in litres which ontain a gram molecular weight of the electrolyte. Mu V s the molecular conductivity at volume V. All the conluctivity measurements were made at a temperature of 5°.

A solution of the double salts, sodium cadmium bromide, vas prepared and standardized by determining the amount f cadmium in a known volume of the solution. From he standarized solution all the remaining dilutions were repared.

* The American Chemical Journal, xvi, 479.

† The American Chemical Journal, xix, 91.

Molecular Conductivity of $2NaBr, 3CdBr_2$ (1022.63).

VOLUME.	FIRST SERIES. Mu V 25°.	SECOND SERIES. Mu V 25°.	MEAN.
2.443	132.8	132.4	132.6
4.886	187.4	187.6	187.5
9.772	248.0	248.2	248.1
19.544	315.9	316.0	315.9
39.088	387.0	387.0	387 0
78.176	457.7	457.8	457.7
97.72	478.3	478.3	478.3
195.44	548.3	548.3	548.3
390.88	625.1	625.5	625.3
781.76	701.6	701.6	701.6
1563.52	780.0	781.6	780.8
3908.80	856.0	857.5	856 8
7817.6	910.7	910.7	910.7
15635.2	958.5	962.4	960.4

Molecular Conductivity of NaBr (103.0).

VOLUME.	FIRST SERIES. Mu V 25°.	SECOND SERIES. Mu V 25°.	MEAN.
1	80.6	80.0	80.3
2	88.0	88.0	88.0
4	94.4	94.4	94.4
8	100.6	101 0	100.8
16	105.3	105.3	105.3
40	110.6	111.1	110.8
80	113.1	113.1	113.1
160	116 6	116.6	116.6
320	119.0	119.4	119.2
640	120.9	1·0.9	120.9
1600	121.1	121.2	121.1

A solution of purified cadmium bromide was standardized by determining the amount of cadmium oxide in a measured volume. From this the remaining dilutions were made in the manner already described.

Molecular Conductivity of $CdBr_2$ (272.21).

VOLUME.	FIRST SERIES. Mu V 25°.	SECOND SERIES. Mu V 25°.	MEAN.
2.60	41.3	41.3	41.3
5.20	57.4	57.4	57.4
10.40	75 7	75.7	75.7
20.80	95.0	95 2	95.1
41.60	115.3	115.4	115.3
104.0	144.1	144.3	144.2
208.0	166.1	166.0	166.0
416.0	188.9	188.7	188.8
832.0	209.3	209.3	209.3
1664.0	228 3	228.2	228.2
3328.0	242.5	242.3	242.4
6656.0	256.3	256.0	256.1

In comparing the conductivity of the double salt with the sum of the conductivities of the constituents twice the molecular conductivity of sodium bromide at one-half the dilution of the double salt is taken. To this is added three times the molecular conductivity of cadmium bromide at one-third the dilution of the double salt. The reason for this is apparent from the composition of the double salt.

Comparison for $2NaBr, 3CdBr_2$.

Volume.	NaBr. Mu V 25°.	Volume	$CdBr_2$ Mu V 25°.	Sum.	Volume.	2NaBr. $3CdBr_2$. Mu V 25°.	Difference.
2.443	179.5	1.63	90.9	270.4	4.88	187.5	82.9
4.886	189.6	3.26	135.9	325 5	9.77	248.1	77.4
9.772	203 6	6.51	185.7	389.3	19 54	315.9	73.4
19.544	212 0	13.03	241.1	453.1	39.09	387.0	66.1
39.088	220.8	26.06	300.0	520.8	78.18	457.7	63 1
48.86	222.6	32.6	318.1	540.7	97.72	478.3	62.4
97.72	227.8	65.1	383.1	610 9	195.44	548.3	62.6
195.44	234.6	130.3	448.1	682 7	390.88	625.3	57.4
390.88	239.6	260.6	515.4	755.0	781.76	701.6	53.4
781.76	242.0	521 2	591.7	833.7	1563.52	780 8	52.9
1563.53	242 4	1302.9	657.9	900.3	3908.8	856 8	43 5
3908.8	242.5	2605.9	705.0	947.5	7817.6	910 7	37.8
7817.6	242.5	5211.7	750.9	993.4	15635.2	960.4	33.0

A NEW DOUBLE BROMIDE OF AMMONIUM AND ZINC.

$3 NH_4 Br, Zn Br_2$.

The constituent bromides were brought together in the proportion to form the double bromide $2 NH_4 Br$. $ZnBr_2$ H_2o as described in the literature. After about two months 100 grams of a well crystallized salt were obtained, and this was analyzed. One anaysis showed the salt to contain 12.8 per cent. of zinc, and a second analysis gave 12.6 per cent. The per centage of zinc in the salt $2 NH_4 Br$, $ZnBr_2$ H_2o is 14.9. It was concluded that either there was present a second double salt containing more than two molecules of ammonium bromide to one of zinc bromide, or that ammonium bromide had crystallized out along with the double salt. A careful examination of the crystals showed that some were apparenty of different habit from the

remainder, being relatively much longer. It therefore seemed probable that a mixture was present. The attempt was then made to recrystallize the salt. It was not possible to obtain it a second time until a large quantity of a solution of the mixture $2NH_4Br, ZnBr_2$ was added. The salt readily crystallized out of this mixture, but again in both the longer and shorter crystals. The longer crystals were now separated mechanically from the shorter and analyzed.

	Calculated for $3NH_4Br, ZnBr_2$.	Found Longer Crystals.	Found Shorter Crystals.
Zn................	12.6	12.8	12.5

To determine whether the salt contained water of crystallization 3.4428 grams were heated for four hours in an air bath at 130°. The loss was 0.9 per cent. The salt was then further heated for four hours at 160° when a slight decomposition took place. The total loss in weight amounted to only 1 per cent. It was therefore concluded that the salt contained no water of crystallization, the slight loss of weight observed being due to water which could not be removed by drying paper on account of the hygroscopic nature of the salt.

The bromine in the salt was then determined by two analyses and found to be 77.24 per cent. The bromine calculated for $3NH_4Br, ZnBr_2$ is 77.01 per cent.

A standard solution of the salt was prepared by determining the zinc in a measured volume of the mother solution.

Conductivity of $3NH_4Br, ZnBr_2$ (519.37).

VOLUME.	FIRST SERIES. Mu V 25°.	SECOND SERIES. Mu V 25°.	MEAN.
1.623	280.1	280.5	280.3
3.246	367.2	367.2	367.2
6.492	417.0	418.1	417.5
12.984	458.9	459.0	458.9
25.968	496.1	496.2	496.1
51.93	518.6	518.6	518.6
64.92	524.9	524.9	524.9
129.84	552.0	553.0	552.5
259.68	570.8	570.9	570.8
519.36	596.4	596.8	596.6
1038.72	621.7	621.8	621.7
2077.4	641.9	641.9	641.9
2596.8	651.0	651.1	651.0
5193.6	675.9	675.9	675.9

The molecular conductivity of ammonium bromide was determined with a specimen which had been repeatedly crystallized, starting with a large quantity of fairly pure salt.

Molecular Conductivity of NH_4Br (98.02).

VOLUME.	FIRST SERIES. Mu V 25°.	SECOND SERIES. Mu V 25°.	MEAN.
0.92	100.0	100.0	100.0
1.84	106.0	106.1	106.0
3.68	111.4	111.2	111.3
7.36	117.3	117.3	117.3
14.72	121.8	122.0	121.9
36.8	127.9	127.7	127.8
73.6	130.9	131.0	130.9
147 2	133.9	133.9	133.9
294.5	137.0	137.3	137.1
588.8	139.7	139.6	139.6
1472.0	141.3	141.1	141.2

The conductivity of zinc bromide in water could not be determined directly, since the bromide is so readily decomposed by water. By comparing a number of chlorides and bromides we find the conductivity of the latter to be about two units greater than the former for equal concentrations. To obtain the conductivity of zinc bromide at any dilution, we have taken the conductivity of zinc chloride at that dilution and added two units. This is, of course, only approximate, but it seems the best that can be done under the conditions.

Comparison for $3NH_4Br.ZnBr_2$.

V.	NH_4Br. 3 Mu V 25°.	*V.*	$ZnBr_2$ Mu V 25°.	Sum.	*V.*	$3NH_4Br$ $ZnBr_2$. Mu V 25°.	Difference.
0.541	285.0	1.623	80.0	365.0	1.623	280.3	84.7
1.08	303.0	3 246	132.5	435.5	3.246	367.2	68.3
2.164	321.3	6 492	148.4	469.7	6.492	417.5	52.2
4.328	337.2	12 984	164.2	501 4	12.984	458.9	42.5
8.656	354.3	25.968	183.9	538.2	25.968	496.1	42.1
21.64	371.4	64.92	192.7	564.1	64.92	524.9	39.2
43.28	385.5	129.84	206.6	592.1	129.84	552.5	39.6
86.56	393.9	259 68	216.6	610.5	259.68	570.8	39.7
173.13	399.0	519 36	222.6	621.6	519.36	596.6	25.0
346.24	411.0	1038.72	226.1	637.1	1038.72	621.7	15.4
865.6	420.0	2596.8	234.5	654.5	2596.8	651.0	3.5
1731.1	423.9	5193.6	237.0	670.9	5193.6	675.9	5.0

Examining the results of the foregoing measurements, the chief point of interest is the magnitude of the "differences" found. These are quite large in the concentrated solutions, and in the case of the double bromide of sodium and cadmium diminish rather slowly with increase of dilution. Indeed at a dilution of 7000 litres, the difference is still 33 conductivity units. The differences for the double bromide of ammonium and zinc are large in the more concentrated solutions, but not so large, for equal dilution, as for the double bromide of sodium and cadmium. These differences decrease much more rapidly with increase in dilution, entirely disappearing at about 1,000 litres.

From the above results the conclusion seems justified, viz.: that the two double bromides exist, to a considerable extent, in the more concentrated solutions, and are completely broken down by water only at very great dilutions.

In conclusion, I desire to thank Dr. H. C. Jones for valuable suggestions and aid in the prosecution of this work.

THE VASCULAR CRYPTOGAMS OF IOWA AND THE ADJOINING PARTS OF SOUTHEASTERN MINNESOTA AND WESTERN WISCONSIN.

BY L. H. PAMMEL AND CHARLOTTE M. KING.

During the past year an excellent paper on Iowa Pteridophyta, by Prof. Shimek, has appeared.

This paper gives the distribution of the Iowa Pteridophytes as they are represented in the Herbarium of the State University of Iowa. The ferns as represented in our collection somewhat extend the limits and give additional localities of others. It is highly desirable that precise localities of our ferns be given, as it is a group of

1. Iowa Pteridophyta in the Herbarium of the State University of Iowa. Bull. Lab. of Nat. Hist. of the State University of Iowa. 5: 145-170, 213-215. 1901.

Figure 6. Bluffs along the Mississippi River, showing the hills sparsely covered with timber above and the densely wooded slopes below; these trees are mostly *Acer nigrum*, *Quercus rubra*, *Ulmus fulva*. Photographed by C. M. King.

plants but sparsely represented in our Iowa flora. With few exceptions they are found only in favored localities.

It will surely add to the value of our knowledge of distribution by giving the ferns found in western Wisconsin and sutheastern Minnesota, a region that has many of the peculiarities of northeastern Iowa.

One of us has collected in the region of La Crosse and southeastern Minnesota, since 1883. This collection, previous to the fire, was almost a complete one. While some specimens were saved, most were lost. The general ecological phases of the region for southeastern Minnesota have been given by Prof. W. A. Wheeler*. Pammel† and Greene‡ have referred to the general character of the region in two short notes.

In a general way the numerous small streams, La Crosse, Mormon Coule, Bad Axe, and Black River intersect the hills and flow into the Mississippi from the east. The Root River and Pine Creek flow into the Mississippi from the west, while the Kickapoo flows into the Wisconsin. On the banks of the thickly wooded bluffs of the Mississippi, bold rocky ledges arise quite abruptly, in many places, from the flood-plain. The lower portions of these ledges are made up of sandstone, the upper being capped with the magnesium limestone. A few lichens, *Arabis lyrata*, *Poa compressa* and some sedges, are found on the limestone, but this region is poor in ferns; the only species occurring is *Pellaea atropurpurea*. However,in the shady gullies and thick timbered groves reaching the escarpments, a luxuriant growth of *Asplenium Felix-foemina*, *Cystopteris fragilis*, *Osmunda Claytonia*, *Adiantum pedatum*, *Onoclea Struthiopteris* and *Pteris aquilina* occur. In the moist gullies, especially in the vicinity of springs, and small, running brooks, *Cystopteris bulbifera* is common. The ridges beyond and above the limestone outcrops are thickly wooded with *Quercus alba*, *Quercus rubra*, *Populus tremuloides* and *Prunus Americana*. Here the common brake (*Pteris aquilina*) is

* A contribution to the knowledge of the flora of Southeastern Minnesota. Minn. Bot. Studies. 2: 353-416. *pl.* 21-27. 1900.

† Botanizing in Western Wisconsin. Plant World. 1: 154. 1898.

‡ Wisconsin Field Notes. Plant World. 2: 17. 1899.

an abundant fern, forming great masses, and with it, in the small draws, *Osmunda Claytoniana*, and *Adiantum pedatum*.

The richest field for ferns is to be found in the lower sandstone outcrops. These are low, rounded greatly eroded hills, and here and there, as along Pine creek in Minnesota and the Tamarack swamp, contain the white pine (*Pinus Strobus*). On these benches, richly laden with moisture from the region beyond; the greatest number of Pteridophytes occur. In the Pine creek region, such species as *Phegopteris polypodioides*, *Phegopteris Dryopteris Pellæa gracilis*, *Woodsia obtusa*, *Polypodium vulgare*, *Aspidium spinulosum*, var *intermedium* and *Lycopodium lucidulum* occur. In the Tamarack region, similar in all respects, an additional species occurs on the exposed sandstone rocks, namely, *Woodsia ilvensis*. The basis of the sandstone rocks, close to the rivers and marshes have such species as *Osmunda cinnamomea*, *Osmunda regalis*, and *Osmunda Claytonia*. The marshes contain *Aspidium Thelypteris* and *Onoclea sensibilis*. The *Selaginella rupestris* is an inhabitant of sandy barrens and dry sandstone rocks. The *Camptosorus rhizophyllus* along the Mississippi occurs on detached limestone rocks, close to the flood-plain.

It is only necessary, in this connection, to make a brief reference to the general features of ferns in central Iowa. The *Cystopteris fragilis* is the most widely distributed fern, found in rich woods. The *Adiantum pedatum* also occurs in rich woods, but they are more moist; the *Asplenium Felix-fœmina* in upland, moist, rich woods, or in small gullies; the *Onoclea* in similar places, but rare. The *Polypodium vulgare*, *Woodsia obtusa* and *Camptosorus rhizophyllus* are found on sandstone ledges; *Onoclea sensibilis* in wet meadows, near springs. It is found in the vicinity of Steamboat Rock, in moist ground, with *Juniperus communis* and *Cypripedium spectabile*.

The Carboniferous sandstone along the Iowa river, in the vicinity of Steamboat Rock, contains such a remarkable instance of northern plants, that a few words regarding them will not be amiss. The white pine (*Pinus Strobus*),

Betula papyrifera, *Betula lenta*, *Populus grandidentata*, *Diervilla trifida* and *Cornus circinata*. In a small grove of the cherry-birch, and places thickly covered with the two birches, may be found an abundance of the *Aspidium marginale*, the only locality, until recently, in the state; also *Phegopteris Dryopteris*, *Phegopteris polypodioides*, *Aspidium spinulosum* var *intermedium*, *Asplenium Filix-fœmina*, *Polypodium vulgare*, *Cystopteris fragilis* and the *Lycopodium lucidulum*. The *Osmunda Claytoniana* is found a few miles further north, along Pine creek, on the damp slope thickly covered with *Carpinus*, *Cornus circinata*, and *Cypripedium spectabile*. A little more drying of the woods and pasturing will exterminate these localities.

NOMENCLATURE.

The question of nomenclature of our ferns is discussed by several recent writers, and there is no unanimity among them. The confusion in names has in part resulted from the subdivisions of genera and the disagreement as to the code of nomenclature to be applied. Dr. Charles Mohr[1] in his excellent monograph on the Plant Life of Alabama, though agreeing in most points with Underwood,[2] uses different names for some of our common ferns, *e. g.*, Bernhard's generic name *Cystopteris*—*C. fragilis* (L.) Bernh. is retained as in Gray's Manual, for which Underwood[3] substitutes the *Felix* of Adanson—*F. fragilis* (L.) Underw. Shimek also uses the Bernhard name as the correct one. Another student of ferns, Mr. Maxon, as regards this genus, uses the Adanson name for this genus. It is useless for us to go into the validity of this name, or the many other changes which are proposed by some, because in the absence of the literature, the citations cannot be verified.

It does seem, however, that before the new names are adopted, that there should be unanimity among those who

1 Plant Life of Alabama. Contr. U. S. Nat. Mus. 6: 310–1901.

2 Our Native Ferns and their Allies, with Synoptical Descriptions of the North American Pteridophyta North of Mexico, 1900. [6th Ed.]

3 A list of the ferns and fern allies of North America, North of Mexico, with the principal synonyms and distribution. Proc. U. S. Nat. Mus. 23: 619, 1901.

propose the changes. We have, therefore, used the nomenclature of Gray's Manual,[4] as it fixes the species for purposes of study.

DISTRIBUTION.

In the distribution of ferns, the paper by Prof. Shimek has been used as well as the papers by Reppert, Miller, Barnes and Witter, and the records given by Prof. Wheeler.

A list of the Vascular Cryptogams of Iowa, as represented in the Herbarium of the Iowa State College, with maps showing distribution according to this list, the list included in the paper Iowa Pteridophyta by Prof. B. Shimek, and the list in the paper, "A contribution to the knowledge of the flora of southeastern Minnesota, by Prof. W. A. Wheeler.

ORDER EQUISETACEÆ.

Equisetum arvense L. Sp. Pl. 1061. 1753.

This, the most common of the Horsetails, is found everywhere in Iowa on sandy banks and in black soils.

IOWA: Ames—*Rolfs*, *Stewart Ball*, *Bessey*. *Hodson*, *Carver;* Clermont—*Walker;* Muscatine—*Reppert;* Keokuk—*Rolfs;* Marshalltown—*Stewart;* Hamilton County—*Rolfs;* Grinnell —*Miss Williams;* Dubuque—*Pammel;* Boone—*Pammel;* Emmet County—*Cratty*.

Equisetum sylvaticum L. Sp. Pl. 1061, 1753.

This has only been reported from one locality. The fact of its occurrence along Skunk river is unusual. It ought to be found in northeastern and eastern Iowa, where the conditions for its occurrence are suitable. It was found in damp, moist banks in a small piece of hemlock woods near Bloomingdale, Wis., and in a tamarack marsh near LaCrosse, Wis.

IOWA: Jasper County—*Norris*.

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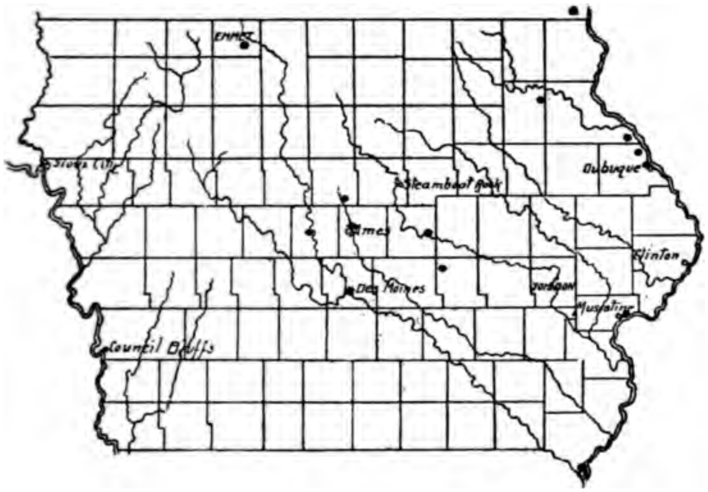
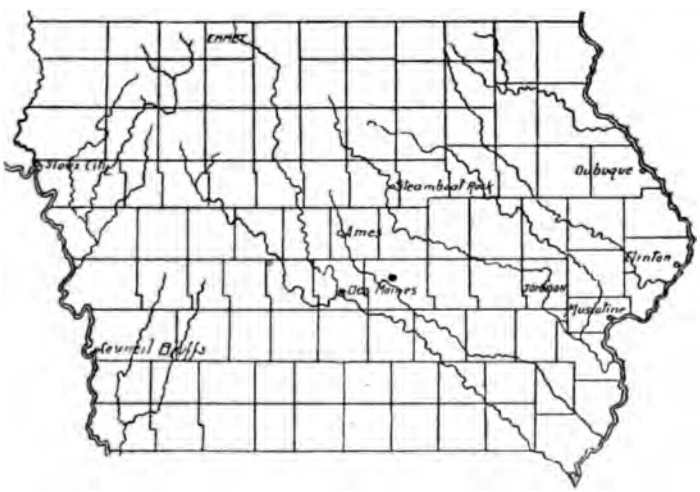
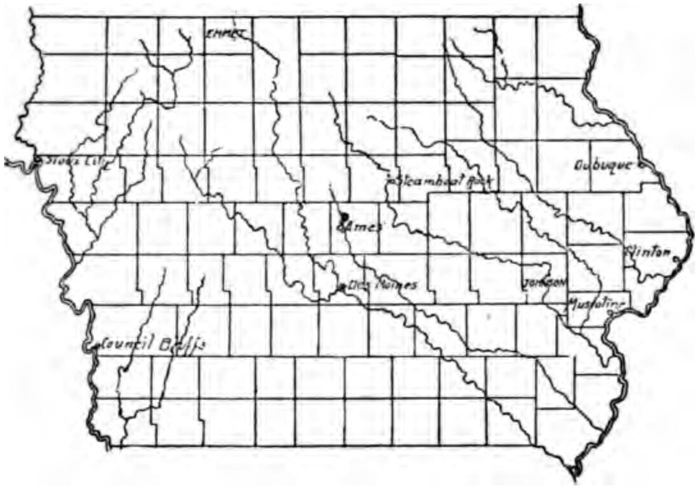
4 Watson and Coulter Gray's Manual. 67?. 1890. [6th Ed.]



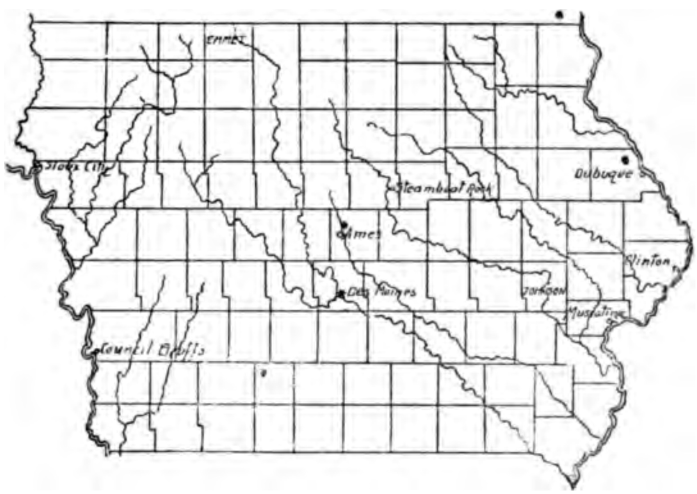
Distribution of *Equisetum arvense* L.



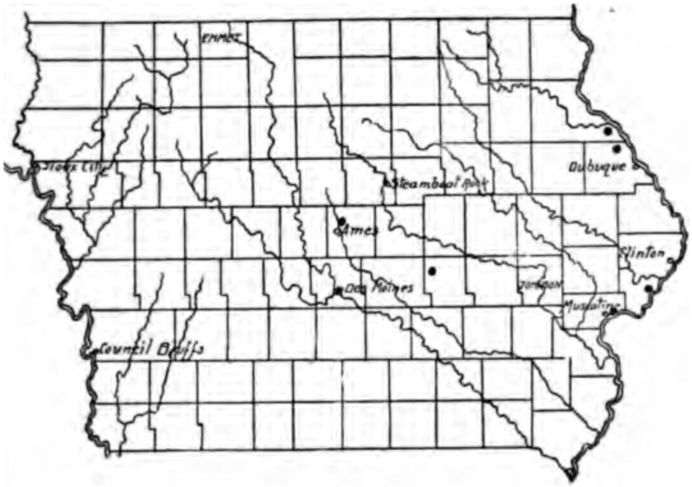
Distribution of *Equisetum sylvaticum* L.



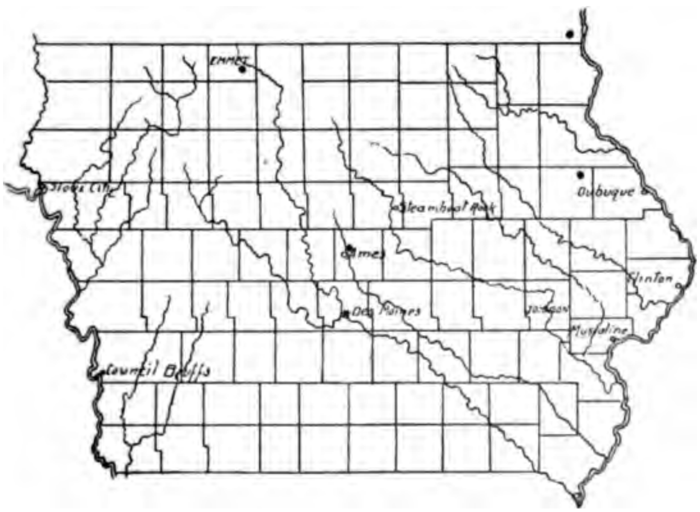
Distribution of ***Equisetum fluviatile*** **L.**



Distribution of *Eqisetum hyemale* L.



Distribution of *Equisetum robustum* A. Br.



Distribution of *Equisetum laevigatum* A. Br.

Equisetum fluviatile L. Sp. Pl. 1062. 1753.

This was much more frequent formerly than now. It occurs in the lake region which occupies the section of Iowa from Ames north to the Minnesota line.

IOWA: Ames—*Hitchcock, Bessey.*

Equisetum hyemale L. Sp. Pl. 1062. 1753.

This species fruits much later than *E. arvense*, and inhabits the same general places.

IOWA: Creston—*Stewart;* Ames—*Hitchcock.*

Equisetum robustum A. Br. Engelmann. Amer. Journ. Sci. **46**: 88. 1844.

This species also fruits much later than *E. arvense*, and is common in rich soils.

IOWA: Le Claire—*Rolfs;* Ames—*Bessey;* Muscatine—*Reppert;* Grinnell—*Miss Williams.*

Equisetum laevigatum A. Br. Engelm. Amer. Journ. Sci. **64**: 78. 1844.

IOWA: Ames—*Miss Adams, Hitchcock;* Emmet County—*Cratty.*

ORDER FILICES.

SUB-ORDER POLYPODIACEAE.

TRIBE POLYPODIEAE.

Polypodium vulgare L. Sp. Pl. 1085. 1753.

So far as we are aware this fern occurs only on sandstone ledges of Carboniferous formation in central and southeastern Iowa. In Wisconsin it is found on the Potsdam sandstone, and is usually associated with *Phegopteris Dryopteris, Vaccinium Pennsylvanicum, Lycopodium lucidulum, Woodsia obtusa*, occasionally *Woodsia ilvensis, Pellaea gracilis* and *Sullivantia Ohionis.* On the Iowa River near Steamboat Rock it is found with *Aspidum marginale, Phegopteris Dryopteris, Woodsia obtusa,*

Aspidium spinulosum var *intermedium*, *Cornus circinata*, *Betula papyrifera* and *Betula lenta*. In Iowa it is not reported west of the Mississippi drainage basin, which is a significant fact. There are undoubtedly many intermediate points between Boone county and the Mississippi River, where it occurs.

IOWA: Allamakee County "common on ledges of St. Peter sandstone"—*Orr;* Steamboat Rock—*Pammel;* Lansing—*Miss King;* Myron—*Miss King;* Wild Cat Den—*Reppert;* Winneshiek County—*Lewis;* Eldora—*Frazier;* Ledges, Boone County—*Pammel*, *Bessey—Miss F. Church.*

SOUTHWEST WISCONSIN: La Crosse—*Pammel;* La Crosse, sandstone rock, tamarack marsh—*Pammel;* Galesville—*Pammel;* Bloomingdale—*Miss Pammel* and *Miss King;* Devil's Lake—*Pammel.*

SOUTHEAST MINNESOTA: Pine Creek—*Pammel.*

TRIBE PTERIDÆ.

Adiantum pedatum L. Sp. Pl. 1095. 1753.

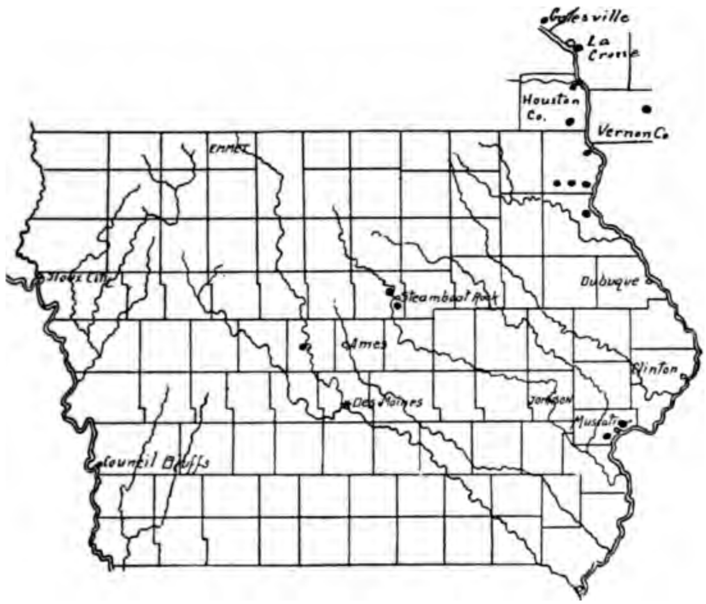
The Maiden-hair Fern has a wider distribution than most of our ferns. It is common to both the Mississippi and Missouri basins and tributaries; but the reported localities from western Iowa are not nearly so numerous as one might expect. It occurs in deep, rich woods, being associated with *Cystopteris fragilis*, but less frequent than that fern.

IOWA: Wildcat Den—*Reppert*, *Ball;* Keokuk—*Rolfs;* Estherville—*Cratty;* Indianola—*Carver;* Monticello—*Bessey;* Lansing—*Miss King;* Myron—*Miss King;* Sedan—*Pammel;* Eldora—*Frazier;* Ames—*Hitchcock;* Steamboat Rock—*Pammel*, *Miss King;* Boone—*Pammel;* Fifteen Mile—Paddock.

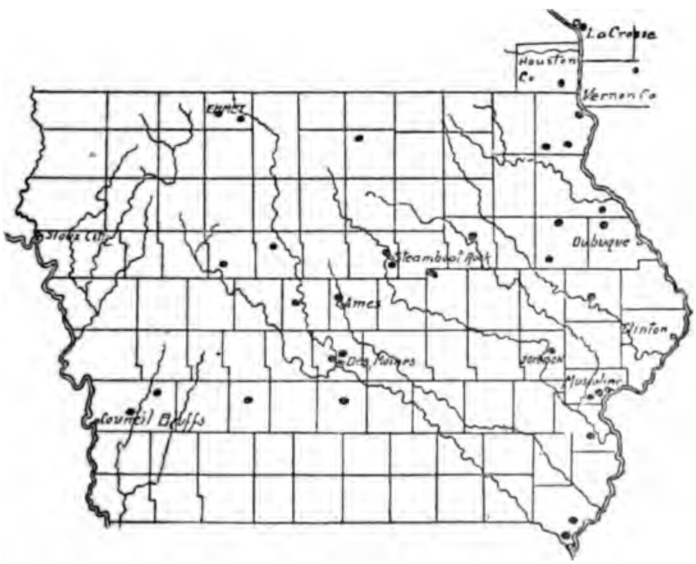
SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel* and *Miss King;* La Crosse—*Pammel.*

Pteris aquilina L. Sp. Pl. 1075. 1753.

The common brake is distributed much the same as *Polypodium vulgare*, but is far less frequent. It is confined

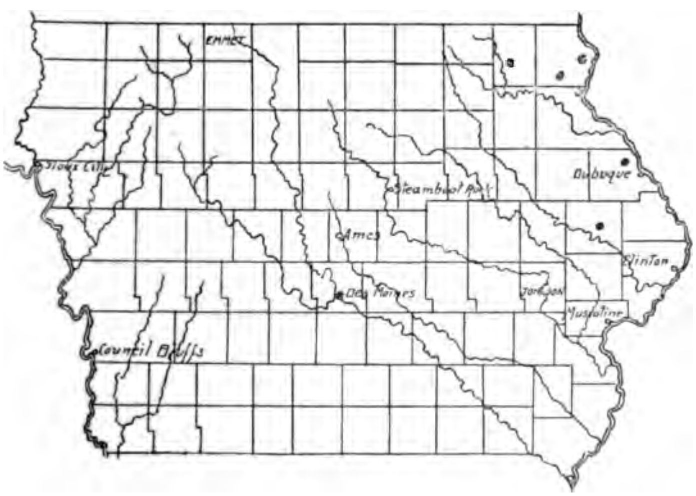


Distribution of *Polypodium vulgare* L.



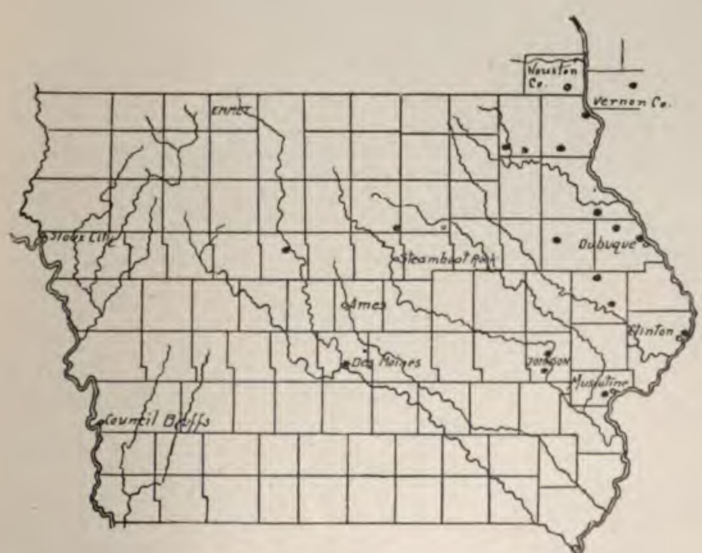
Distribution of *Adiantum pedatum* L.

Distribution of *Pteris aquilina* L.



Distribution of *Cheilanthes lanuginosa* Nutt.

Distribution of *Pellæa gracilis* Hook.



Distribution of *Pellæa atropurpurea* Link.

Figure 2. The Cliff Brake (*Pellaea gracilis* Hook) from West Union, Iowa, on sandy rocks.

to the Mississippi basin, reaching its greatest development in northeastern Iowa, where it is a common inhabitant of oak woods, either in sandy or clay soil. The associated plants are *Adiantum pedatum*, *Pedicularis canadensis*, *Anemonella thalictroides* and *Cypripedium pubescens*. At Steamboat Rock it is more common than at Ames. At Ames it is about extinct. It is more frequent at Muscatine and at Lebanon in southeastern Iowa.

IOWA: Muscatine—*Reppert;* Ames, "one mile northwest of Iowa State College, in rich woods"—*Hitchcock;* Wildcat Den—*Ball;* Myron—*Miss King;* Lansing—*Miss King;* Postville—"common in Allamakee county"—*Orr;* Lebanon—*Sample;* Ames—*Carver;* Monticello—"woods," *Bessey;* New Albin—*Pammel;* Steamboat Rock—*Pammel.*

SOUTHWESTERN WISCONSIN: La Crosse—*Pammel;* Bloomingdale—*Miss Pammel* and *Miss King.*

SOUTHEASTERN MINNESOTA: Pine Creek—*Pammel.*

Cheilanthes tomentosa Link.

There is one specimen in the College collection taken from a cultivated specimen, collected by Mr. Carver, and presumably from southeastern Iowa; but the specimen contains no further data. If this came from Iowa it is north of its range.

Cheilanthes lanuginosa Nutt.; Hooker. Sp. Fil. 2: 99. 1858.

This small fern occurs on limestone rocks, generally along the Mississippi river and tributaries, but it is not common. It is associated with *Pellaea atropurpurea.*

IOWA: Allamakee County "Oneota limestone—bluffs"—*E. Orr;* Winneshiek County—*Lewis;* North McGregor—*Pammel.*

Pellæa gracilis Hook. Sp. Fil. 2: 138. 1858.

The distribution of this fern is rather limited, and so far as we know, it is always found on sandstone ledges. The shady sandstone ledges that underlie the magnesian lime-

stone in southwestern Wisconsin and southeastern Minnesota contain this fern, but never in large areas. There is a great deal of this fern along the Kickapoo river, in the vicinity of Bloomingdale, growing with *Sullivantia Ohionsis*, *Mitella diphylla*, *Diervilla trifida*, *Vaccinium Pennsylvanicum*, *Phegopteris Dryopteris* and *Lpcopodum lucidulum*.

Iowa: Allamakee County, "seven miles northeast of Postville, on Balsam Fir bluff, Yellow river"—*Orr;* Winneshiek County—*Lewis;* Delaware County—*MacBride.*

Southwestern Wisconsin: La Crosse—*Pammel;* Rockton—*Pammel.*

Southeastern Minnesota: Pine Creek "not represented by a specimen"—*Pammel.*

Pellæa atropurpurea Link. Fil. Hort. Berol. 59. 1841.

This fern is found on limestone rocks, confined to the Mississippi river and its tributaries.

Iowa: Allamakee County, Yellow River, "common on limestone bluffs"—*Orr;* Lansing—*Miss King;* Ackley—*Hunt;* Dubuque—*Pammel;* Monticello—*Bessey;* Muscatine County, Wyoming Hills, "in clefts of a lime-bearing sandstone"—*Reppert;* Winneshiek County—*Lewis;* Fort Dodge, "limestone cliffs"—*Bessey;* Iowa City—*Hitchcock;* Clinton—*Pammel;* Cedar Rapids—*Pammel.*

Southwestern Wisconsin: Bloomingdale—*Miss Pammel* and *Miss King.*

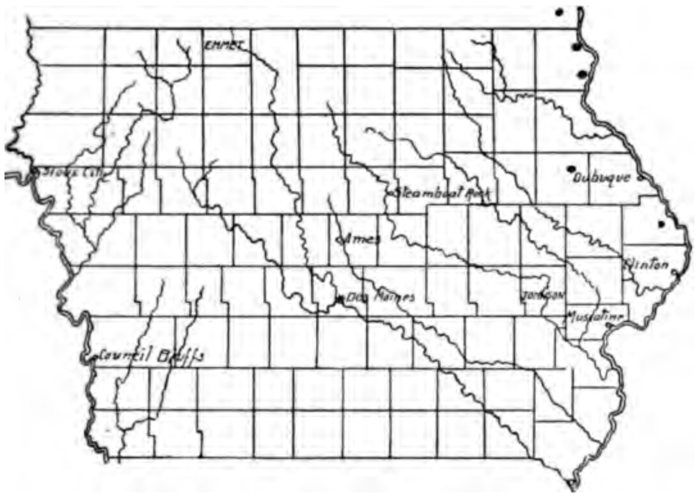
TRIBE ASPLENIEÆ.

Asplenium angustifolium Michx. Fl. Bor. Am. 2: 265. 1803.

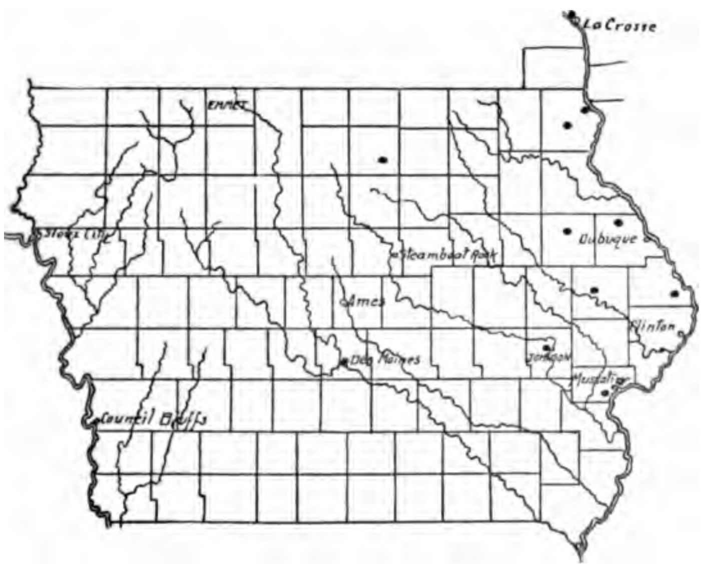
Its distribution in northeastern Iowa indicates an invasion from Wisconsin. It does not occur in southeastern Minnesota (Houston county) so far as known.

Iowa: Waukon Junction, "heavy woods at base of Mississippi river bluff"—*Orr;* Lansing, "similar situation"—*Miss King.*

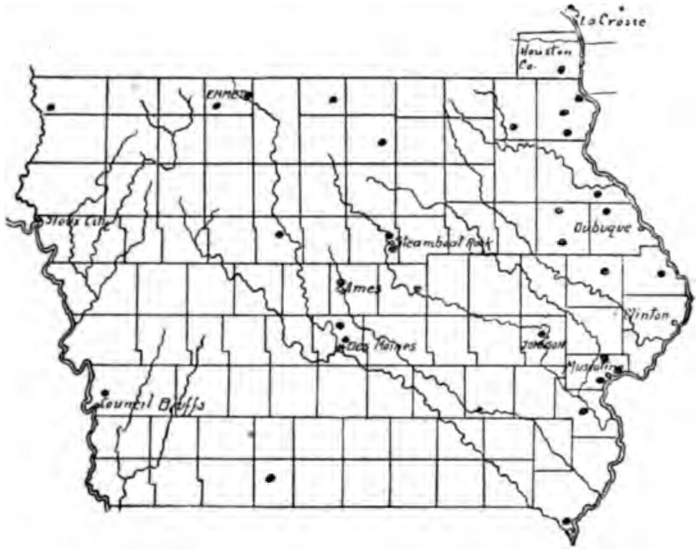
Figure 3. *Asplenium Felix-foemina* under calcareous rocks, Indian Creek, Cedar Rapids, Iowa. Photographed by L. H. Pammel.



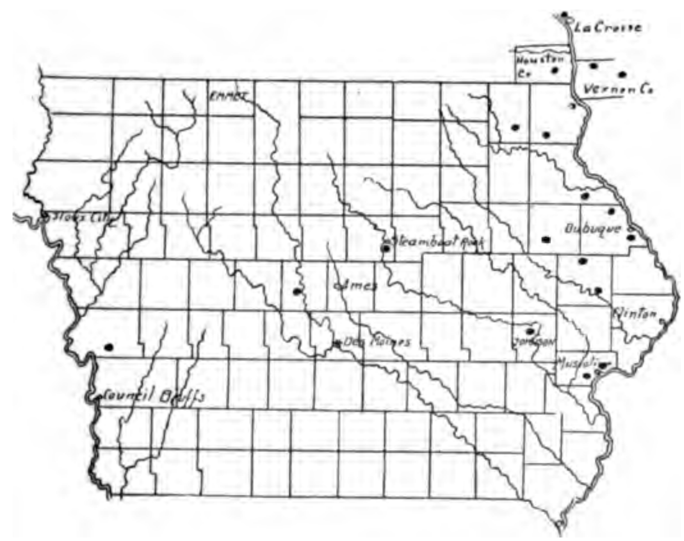
Distribution of *Asplenium angustifolium* Michx.



Distribution of *Asplenium thelypteroides* Michx.



Distribution of *Asplenium Felix-foemnia* Bernh. Echrad.



Distribution of *Camptosorus rhizophyllus* Link.

Asplemium thelypteroides Michx.

Though a common fern eastward, it is not common in this state. It occurs in rich woods. It extends further westward than *A. angustifolium*.

IOWA: Waukon "not common"—*E. Orr;* Muscatine County—*MacBride, Reppert;* Lansing—*Miss King.*

SOUHEASTERN WISCONSIN: La Crosse—*Pammel.*

Asplenium Felix-foemina Bernh. Schrad. Neues Journ Bot. 1[2]: 26. 1806.

This is another of the widely distributed ferns of Iowa, occurring in the Missouri and Mississippi river flood-plains; most common in the eastern portion of the state. It is found in deep, rich woods; specimens three feet high are not uncommon. From Iowa it has extended into Missouri.

IOWA: Wild Cat Den—*Ball, Pammel* and *Reppert;* Ames—*Hitchcock, Bessey;* Marshalltown—*Stewart;* Monticello—*Bessey;* Wilton—*Hitchcock;* Eldora—*Frazier;* Armstrong—*Cratty;* Keokuk—*Rolfs;* Winneshiek County—*Lewis;* Polk County—*Bessey;* three miles east of Waukon—*E. Orr;* Steamboat Rock—*Pammel;* Lansing—*Miss King.*

WISCNSIN: LaCross, Bloomingdale—*Pammel.*

MINNESOTA: Pine Creek—*Pammel.*

Camptosorus rhizophyllus Link. Hort. Berol. 2: 69. 1833.

This fern is confined chiefly to the Mississippi basin. In northeastern Iowa and in Wisconsin this fern is found on detached limestone rocks, at the base of bluffs. But at Steamboat Rock and in Boone County, it occurs on the Carboniferous sandstone.

IOWA: Allamakee County, "on detached fragments from bluffs"—*E. Orr;* Des Moines River—*Bessey;* Wild Cat Den—*Pammel and Reppert;* Missouri Valley—*Miss Crawford;* Monticello—*Doxsee;* Ledges, Boone County—*Bessey, Miss F. Church;* Eldora—*Frazier;* Wild Cat Den—*Reppert;* Lansing—*Miss King;* Cedar Rapids—*Buchanan.*

SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel and Miss King;* Coon Valley—*Pammel;* La Crosse "limestone rocks"—*Pammel.*

MINNESOTA: Pine Creek—*Pammel.*

TRIBE ASPIDIEÆ.

Phegopteris polypodioides Fee. Gen. Fil. 243. 250-252. 1850-52.

IOWA: Myron—*Miss King.*

SOUTHWESTERN WISCONSIN: La Crosse—*Pammel.*

SOUTHEASTERN MINNESOTA: Pine Creek—*Pammel.*

Phegopteris hexagonoptera Fee. Gen. Fil. 243. 1850-1852.

This southern fern is most frequent in southern and southeastern Iowa. Several specimens from Allamakee county and one from Steamboat Rock, though not typical, we have referred to this species. The Steamboat Rock specimens may not be unusual, as *Melica diffusa*, another southern plant, has found its way as far north as this point. In Muscatine county the species occur in somewhat damp clay, sandy woods, while at Steamboat Rock it is found in black, rich, sandy woods.

IOWA: Waukon Junction, "Mississippi river bluffs"—*E. Orr;* Wild Cat Den—*Ball;* Steamboat Rock—*Pammel;* Lansing *Miss King;* Muscatine, "in rich woods, frequent"- *Reppert.*

Phegopteris Dryopteris Fee. Gen. Fil. 243. 1850-1852.

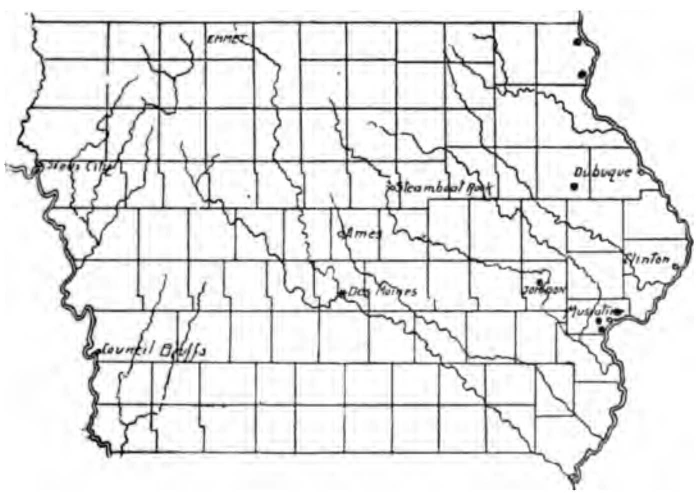
Usually in moist, shady, sandy banks with white pine, *Woodsia ilvensis, Lycopodium lucidulum.* At Steamboat Rock, in sandy banks, it is very abundant locally with *Aspidium marginale, Asplenium Felix-foemina, Diervilla trifida* and *Betula lenta.*

IOWA: Allamakee County, "seven miles north of Postville, on Yellow river, Balsam Fir bluff"—*E. Orr;* Steamboat Rock—*Miss King;* Eldora—*Frazier.*

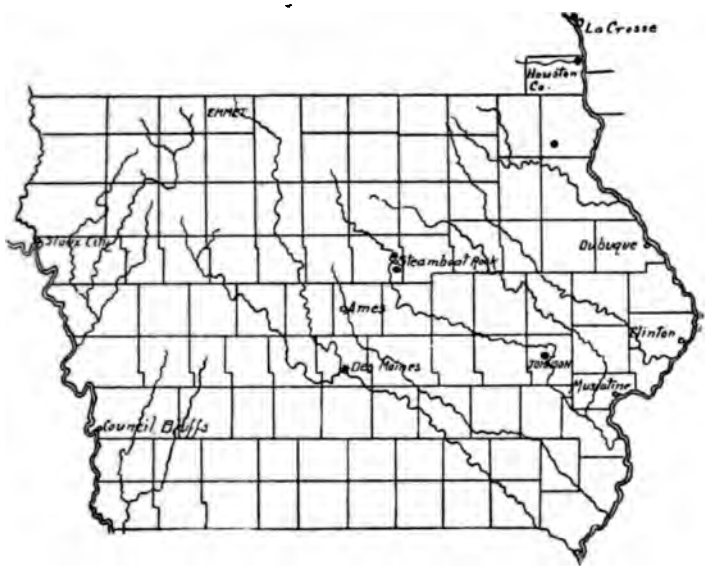
SOUTHWESTERN WISCONSIN: La Crosse—*Pammel.*

SOUTHEASTERN MINNESOTA: Houston county, Pine Creek, near La Crescent—*Pammel.*

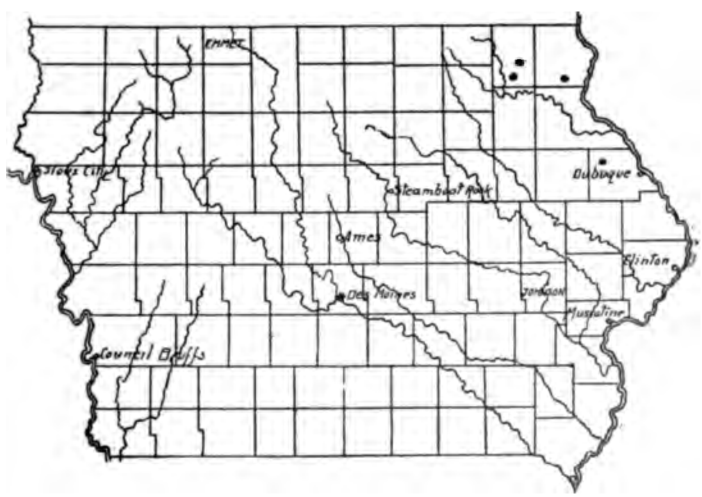
Distribution of *Phegopteris polypodioides* Fee.



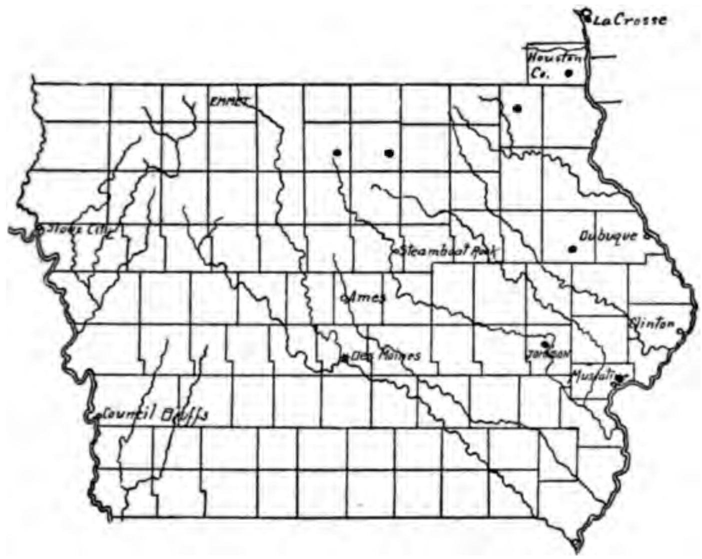
Distribution of *Phegopteris hexagonoptera* Fee.



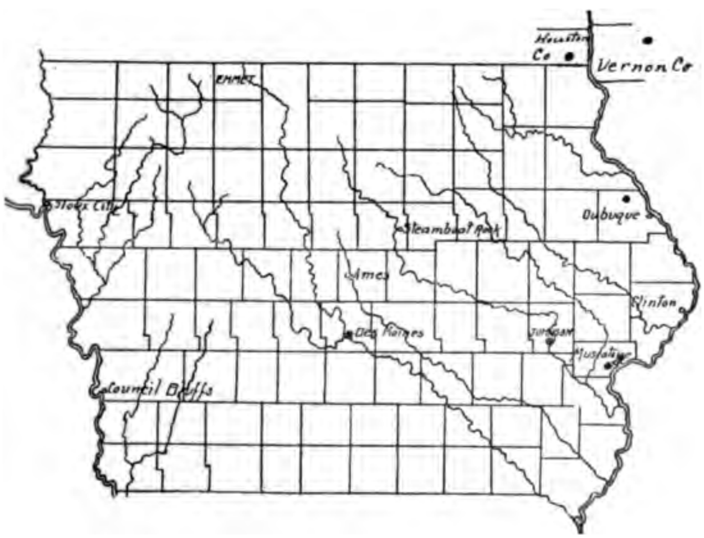
Distribution of *Phegopt ris Dryopteris* Fee.



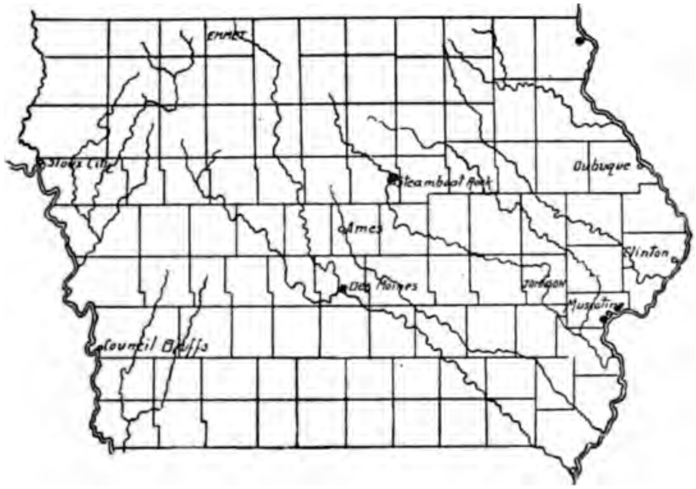
Distribution of *Phegopteris calcarea* Fee.



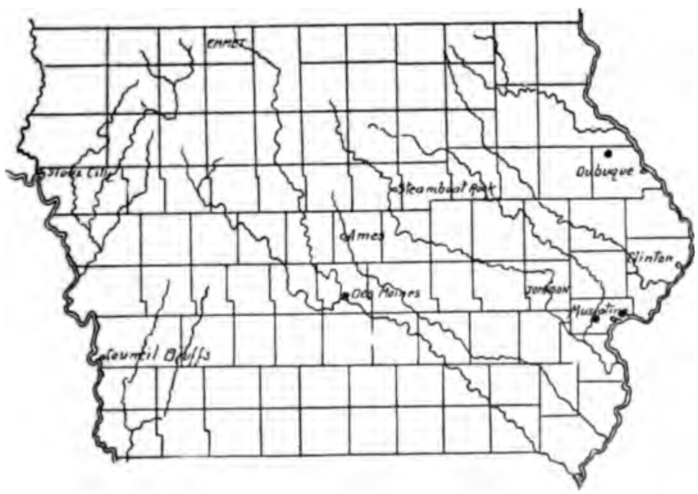
Distribution of *Aspidium Thelypteris* Sw. Schrad.



Distribution of *Aspidium spinulosum* Sw. Schrad.



Distribution of *Aspidium spinulosum* var *intermedium* Muhl.



Distribution of *Aspidium cristatum* Sw.

Aspidium cristatum and *Osmunda regalis* on the border of Tamarack Marsh.
arge *Cypripedium spectabile*, La Crosse, Wisconsin, Town of Campbell. Pho-
ed by L. H. Pammel.

Phegopteris calcarea Fee. Gen. Fil. 243. 1850–52.

This interesting species was first reported by Mr. Holway. It is one of the rarest ferns in Iowa.

IOWA: Decorah, "in moss, north side of bluff"—*Holway.*

Aspidium Thelypteris Sw. Schrad. Journ. Bot. 2: 40. 1800.

This fern is abundant in swamps and low ground, especially in western Wisconsin and southeastern Minnesota—so abundant in places as to be a common ingredient of hay.

IOWA: Muscatine, "in wet and swampy places, frequent"—*Reppert;* Winneshiek County—*Lewis.*

SOUTHWESTERN WISCONSIN: La Crosse, "sedge swamp"—*Miss King;* La Crosse—*Pammel.*

Aspidium spinulosum Sw. Schrad. Journ. Bot. 2: 38. 1800.

This is another rare fern; at Muscatine it occurs under the sandstone carboniferous ledge.

IOWA: Wild Cat Den—*Reppert.*

SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel* and *Miss King.*

Aspidium spinulosum var *intermedium* D. C. Eaton in A. Gray, Man. Ed. 5, 665. 1867.

Another rare fern for the state. It occurs in a number of situations, and has evidently a wider distribution than the species. Its associates at Steamboat Rock are the same as for *A. marginale.* It is not, however, as abundant. It is not common at La Crosse, but more abundant in the Kickapoo valley.

IOWA: Steamboat Rock—*Pammel, Miss King;* Lansing—*Miss King.*

Aspidium cristatum Sw. Schrad. Journ. Bot. 2: 37. 1800.

This fern is not infrequent in tamarack swamps in the vicinity of La Crosse and Galesville, occurring with *Viola canina* and *Cypripedium spectabile.*

IOWA: Muscatine County, "hillside bogs near Cedar river, Lake Township, and damp ravines in various places—infrequent"—*Reppert.*

Aspidium Goldieanum Hook. Edinb. Philos. Journal. 6: 333. 1822.

Locally this is abundant, the Carboniferous sandstone, growing with *Pinus Strobus.*

IOWA: Waukon Junction, "not common—found in deep woods at foot of bluffs"—*E. Orr;* Eldora—*Frazier;* Wild Cat Den—*Pammel* and *Reppert;* Muscatine County—*Reppert;* Lansing—*Miss King.*

Aspidium marginale Sw. Syn. Fil. 50. 1806.

The occurrence of this fern in Iowa has not been reported before. There are but three recorded localities in the state; two in Hardin County, and one in northeastern Iowa, near Postville, some one hundred and seventy-five miles apart. Though one of us diligently searched the country in La Crosse, Trempleau and Vernon Counties, in Wisconsin, and Houston County, in Minnesota, for this fern, it has not been found. It is, however, abundant at Devil's Lake, Wisconsin, where it occurs on granite rocks. It is certainly not common except northward and eastward, and again in the Ozark region in Missouri, where granite rock occurs. At Steamboat Rock it is locally very abundant at the base of sandstone ledges along the Iowa river. For Iowa, this is an extremely rare fern. *Phegopteris Dryopteris*, *Diervilla trifida* and *Betula lenta* are its associates.

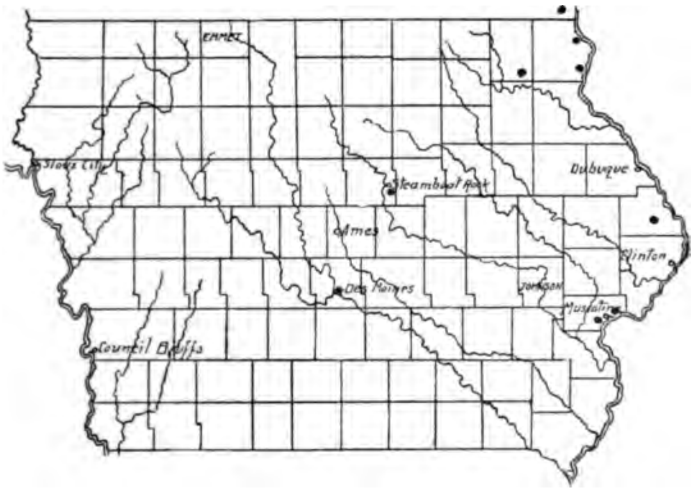
IOWA: Steamboat Rock—*Pammel, Miss King;* Eldora—*Frazier;* Postville, "woods"—*Miss King.*

Aspidium acrostichoides Sw. Syn. Fil. 44. 1806.

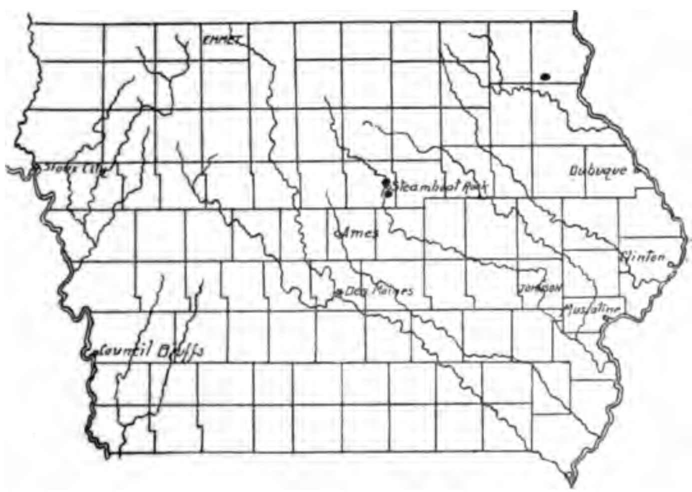
This northern fern is locally abundant in Muscatine, growing with the *Vitis cinerea* in deep, rich woods.

IOWA: Wild Cat Den—*Shimek, Ball;* Muscatine—*Reppert;* Keokuk—*Ehinger.*

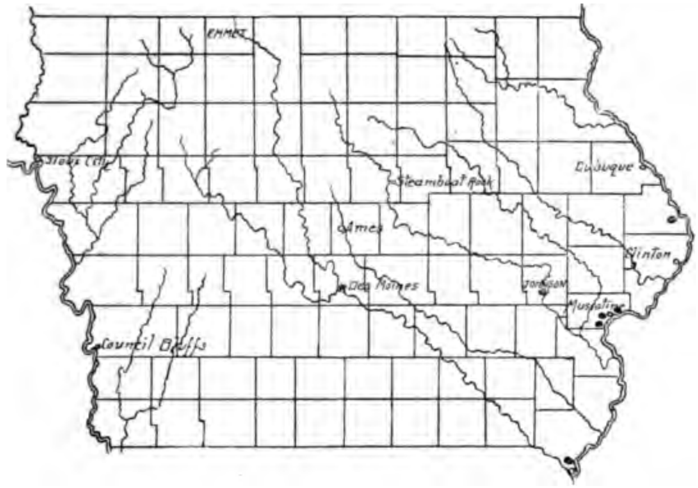
Figure 5. *Aspidium marginale* in the middle of a bank of ice, near Steamboat Rock, Iowa, April, 1901. Photographed by L. H. Pammel.



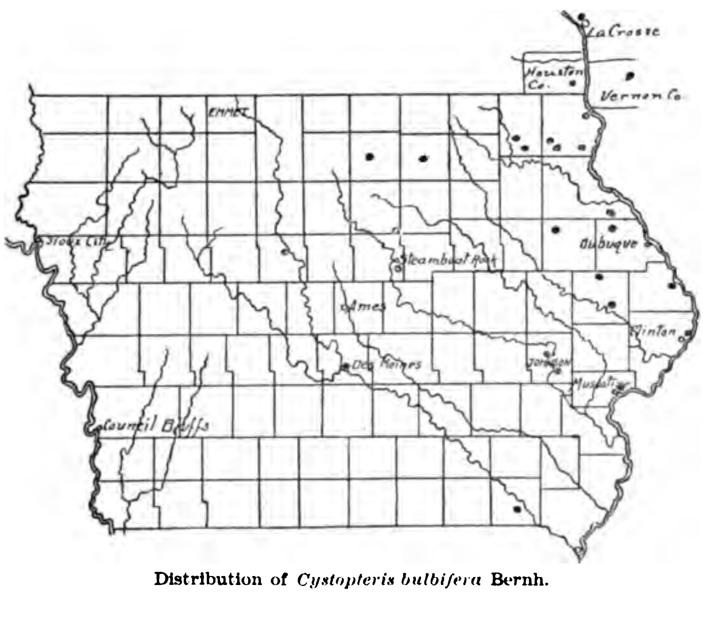
Distribution of *Aspidium Goldieanum* Hook.



Distribution of *Aspidium marginale* Sw.



Distribution of *Aspidium acrostichoides*, Sw.



Distribution of *Cystopteris bulbifera* Bernh.

Aspidium Lonchitis Sw. Schrad. Journ. Bot. 2: 30. 1800

IOWA: Des Moines River, collector unknown. It is more than probable that this specimen is not from Iowa. It bears an old label and was placed in the collection by Dr. Bessey. Its occurrence in Iowa would be remarkable. It is a northern fern, of the Lake Superior region. It is not mentioned by Prof. Shimek, who has been a close observer and student of ferns.

Cystopteris bulbifera Bernh. Schrad. Neues. Journ. Bot. 1²: 26. 1806.

This fern is confined to the Mississippi River basin, occurring in deep, shaded ravines in the vicinity of streams and small brooks, on sandstone rocks, sandy soil or in loamy moist soil. It is most abundant in northeastern Iowa.

IOWA: Allamakee County, "common"—*E. Orr;* Iowa City—*Shimek;* Myron—*Miss King;* Lansing—*Miss King;* Clinton—*Pammel;* Lebanon—*Sample;* Eldora—*Frazier;* Muscatine County—*Reppert;* Monticello—*Bessey;* Ackley—*Canavon;* Winneshiek County, "from limestone bluffs at Coldwater Cave"—*Lewis;* Charles City—*Arthur;* Iowa City—*Hitchcock.*

SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel and Miss King;* La Crosse—*Pammel;* Rockton—*Pammel.*

Cystopteris fragilis. Bernh. Schrad. Neues Journ. Bot. 1²: 27. 1806.

This is the most widely distributed of all our ferns, occurring in the Mississippi and Missouri river basins. It is common in all our rich woods, less frequent, however, in the Missouri.

IOWA: Ames—*Bessey, Hitchcock;* Mason City, "under limestone cliffs"—*Arthur;* Monticello, *Bessey;* Winneshiek County—*Lewis;* Muscatine County—*Reppert;* Eldora—*Frazier;* Steamboat Rock—*Miss King;* Cedar Rapids—*Pammel;* Grundy Center—*Miss Paddock;* Ledges, Boone County—*Pammel;* Moingona—*Pammel;* Allamakee County,

Yellow River, "abundant"—*E. Orr;* Lansing—*Miss King;* Iowa City—*Hitchcock;* Des Moines—*Mrs. Steavens.*

SOUTHWESTERN WISCONSIN: Galesville—*Pammel;* Bloomingdale—*Pammel;* Rockton—*Pammel;* La Crosse—*Pammel.*

Onoclea sensibilis L. Sp. Pl. 1062. 1753.

Common in moist, springy places in southeastern Minnesota, and in La Crosse, Trempleau and Vernon counties, Wisconsin. It forms solid masses in places. It is confined to the Mississippi river basin.

IOWA: Moulton—*Pammel;* Cedar Falls—*Carver;* Ames, "three miles north of Ames"—*Hitchcock;* "northeastern Iowa"—*Henry;* Muscatine, "moist woods, boggy meadows, and on Islands in the Mississippi river--common"—*Reppert;* Iowa City—*Hitchcock.*

SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel* and *Miss King.*

Onoclea Struthiopteris. Hoffm. Deutsch. Fl. 2: 11. 1795.

Widely distributed, but never abundant, in deep, rich, moist woods; frequently reaches a height of five feet. It is more frequent in northeastern Iowa than the localities indicate. It is abundant in Houston county, Minnesota, and in La Crosse and Vernon counties, Wisconsin.

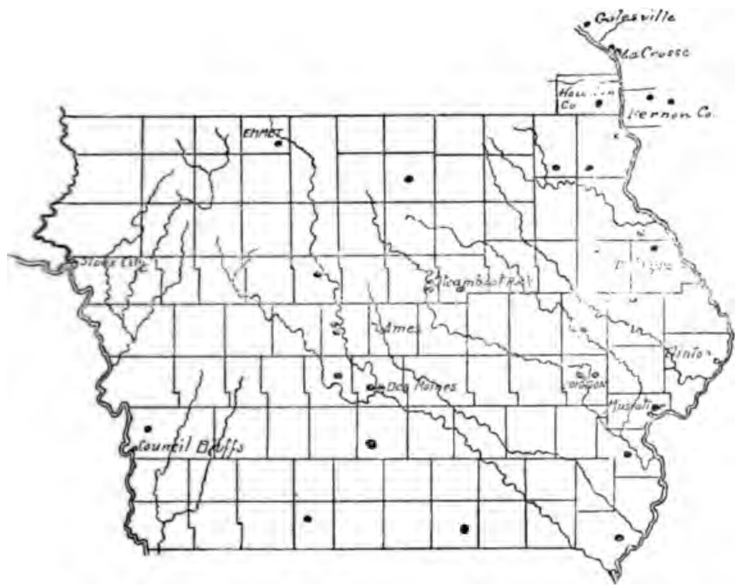
IOWA: Waukon Junction, "banks of the Mississippi River"—*E. Orr;* Wild Cat Den—*Reppert;* Winneshiek County—*Lewis;* Ames—*Pammel.*

SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel* and *Miss King;* Stoddard—*Pammel* (not represented by specimen).

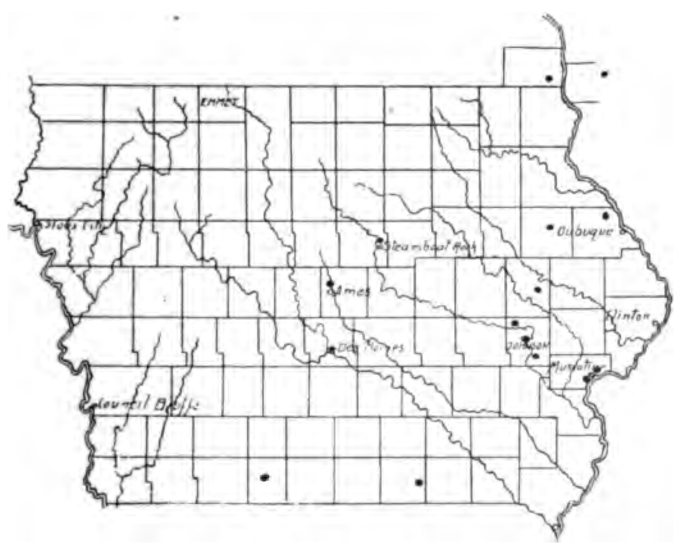
TRIBE WOODSIEÆ.

Woodsia Ilvensis R. Br. Trans. Linn. Soc. 11: 173. 1812.

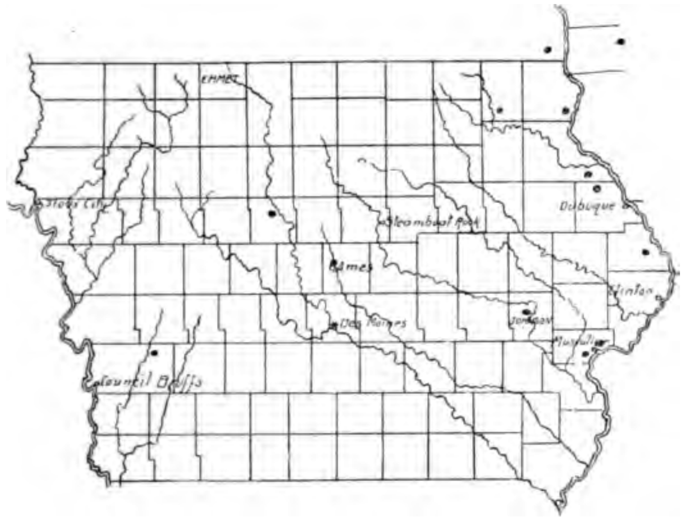
This fern has not been reported for Iowa, nor is it common in Houston county, Minnesota. It is local in La Crosse and Trempleau counties, but abundant on the sandstone



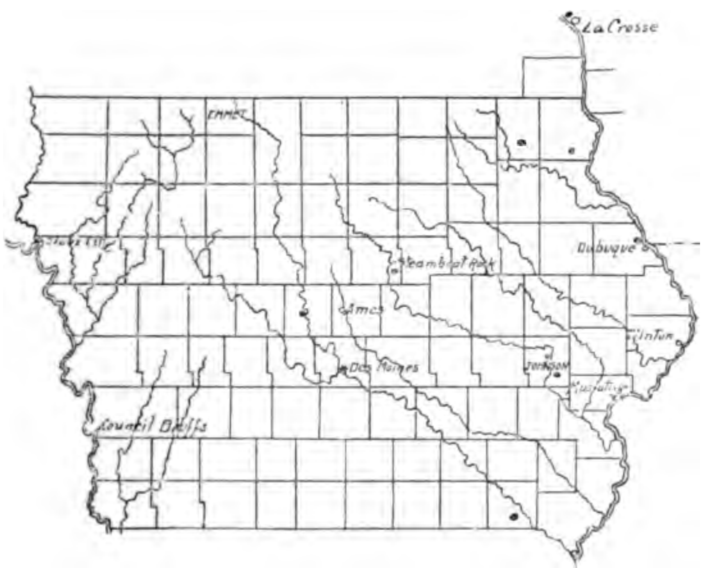
Distribution of *Cystopteris fragilis* Bern.



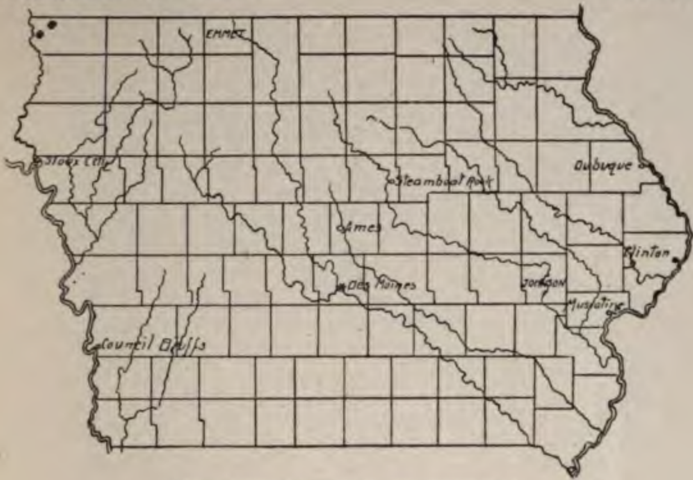
Distribution of *Onoclea sensibilis* Hoffm.



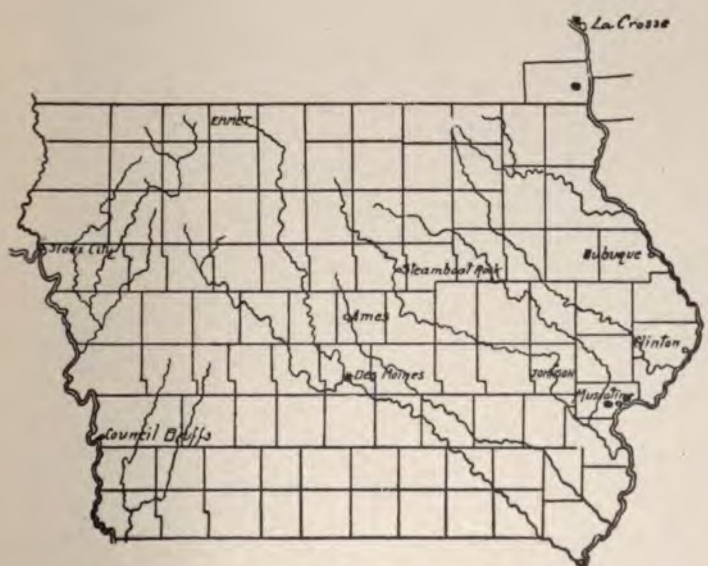
Distribution of *Onoclea Struthiopteris* (L.) Hoffm.



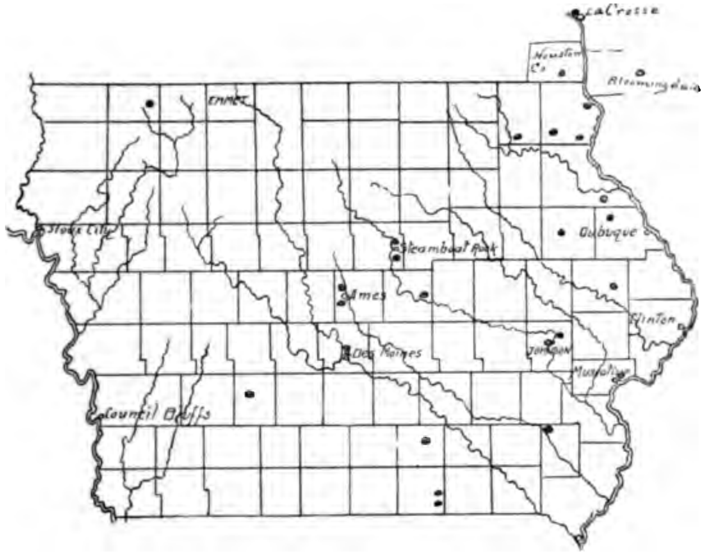
Distribution of *Woodsia obtusa* Torr.



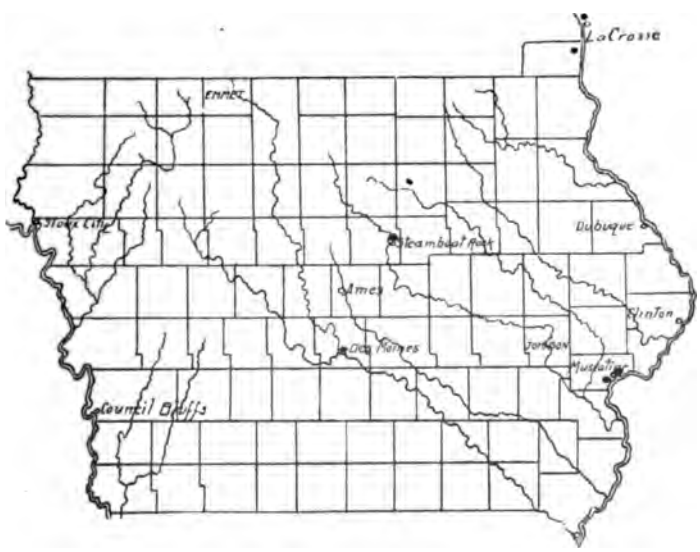
Distribution of *Woodsia scopulina* D. C.



Distribution of *Osmunda regalis* L.



Distribution of *Osmunda Claytoniana* L.



Distribution of *Osmunda cinnamomea* L.

A fern patch. *Osmunda Claytonia*; in lower right hand corner *Cystopteris bulbifera*, Bloomingdale, Wisconsin.

rocks of the Wisconsin river, in the vicinity of Kilbourn City, where it is found on the more exposed rocks.

SOUTHWESTERN WISCONSIN. La Crosse, "sandstone rock, Tamarack swamp"—*Pammel.*

SOUTHEASTERN MINNESOTA: Pine Creek—*Pammel.*

Woodsia obtusa Torr. Cat Pl. in Geol. Rep. N. Y. 195. 1840.

Quite widely distributed in eastern Iowa, with *Polypodium vulgare*, never abundant. It is more abundant in southeastern Minnesota, La Crosse, Vernon, Trempleau and Vernon counties, Wisconsin. Here it is always found on sandstone rocks.

IOWA: Allamakee County, Yellow River, one mile below ·on—*E. Orr;* Lebanon—*Sample;* Eldora—*Frazier;* Ledges, Boone County—*Pammel, Combs* and *Miss F. Church;* Dubuque—*Pammel;* Iowa City—*Hitchcock;* Winneshiek County—*Lewis;* Muscatine County—*Reppert.*

SOUTHWESTERN WISCONSIN: La Crosse, "on sandstone rock, tamarack swamp"—*Pammel;* La Crosse—*Pammel.*

Woodsia scopulina D. C. Eaton, Can. Nat. 2: 90. 1865.

IOWA: Lyon County—*Shimek.*

SUBORDER OSMUNDACEÆ.

Osmunda regalis L. Sp. Pl. 1065. 1753.

This is rare in Iowa, though frequent in Houston county, Minnesota, and La Crosse County, Wisconsin; found in moist meadows, along streams and in tamarack swamps.

IOWA: Muscatine County—*Reppert.*

SOUTHEASTERN MINNESOTA: Houston County—*Pammel.*

SOUTHWESTERN WISCONSIN: La Crosse—*Pammel.*

Osmunda Claytoniana L. Sp. Pl. 1066. 1753.

This species is more widely distributed than any of the other species, occurring in deep, rich woods, frequently attaining a height of four feet.

IOWA: North of Postville, "common in heavy woods throughout the county"—*E. Orr;* Iowa City—*Herb, S. U. I.;* Lansing—*Miss King;* North of Ames—*Pammel;* Moulton—*Pammel;* Sedan—*Pammel;* Steamboat Rock—*Pammel;* Wayland—*Carver;* Ames—*Hitchcock;* Marshalltown—*Stewart;* Muscatine—*Reppert;* Winneshiek County—*Lewis;* Iowa City—*Hitchcock;* Ames, "dry woods"—*Thomas;* Eldora—*Frazier;* Des Moines, Osceola County and Monroe County observed—*Pammel;* Des Moines—*Mrs. Steavens.*

SOUTHWESTERN WISCONSIN: La Crosse—*Pammel;* Bloomingdale—*Miss Pammel* and *Miss King.*

Osmunda cinnamomea L. Sp. Pl. 1066. 1753.

Rich, damp woods, not abundant. Near Steamboat Rock on side hills; but in southeastern Minnesota on shady, sandy banks of streams; in La Crosse and Trempleau counties, Wisconsin, on sandy banks, and in Tamarack swamps.

IOWA: Muscatine County, "seems to be rare, as yet found only in Lake township, in a wooded ravine on 'Chicken Creek'"—*Reppert;* Steamboat Rock—*Pammel.*

SOUTHEASTERN MINNESOTA: Pine Creek—*Pammel.*

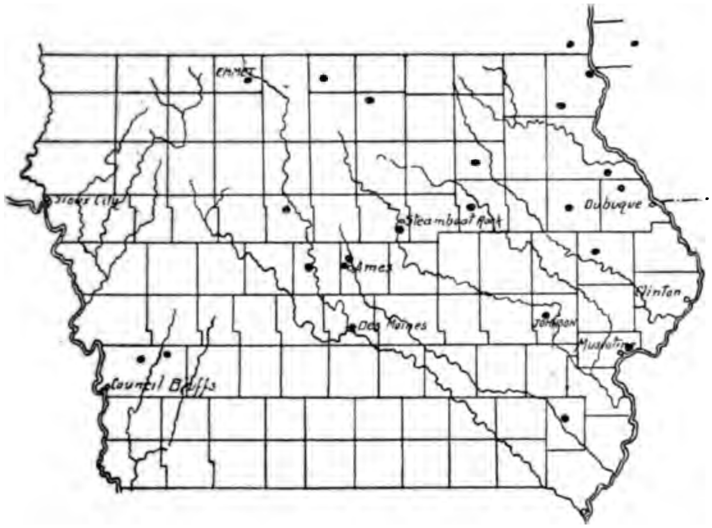
SOUTHWESTERN WISCONSIN: La Crosse—*Pammel;* Trempleau county—*Pammel.*

ORDER OPHIOGLOSSACEAE.

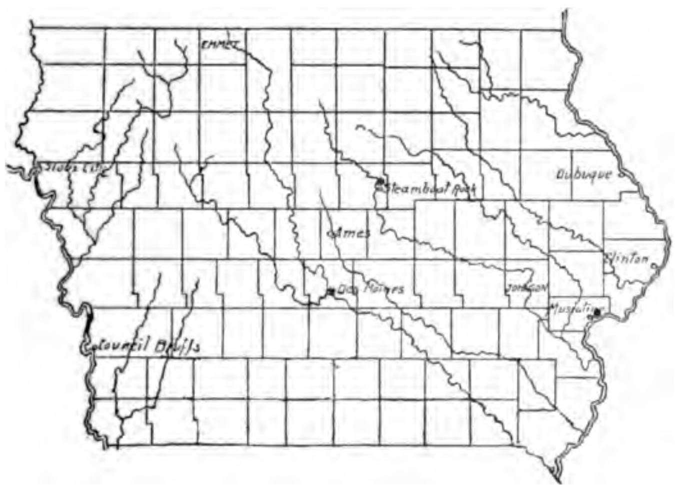
Botrychium virginanum. Sw. Schrad, Journ. Bot. 2: 111. 1800.

IOWA: North of Postville, "heavy woods"—*E. Orr;* Lansing—*Miss King;* North of Ames—*Miss Paddock;* Ledges, Boone Co.—*Pammel and Combs*; Muscatine Co.—*Reppert*; Eldora—*Frazier*; Ames—*Hitchcock*, *Bessey*, *Pammel;* Des Moines—*Mrs. Steavens.*

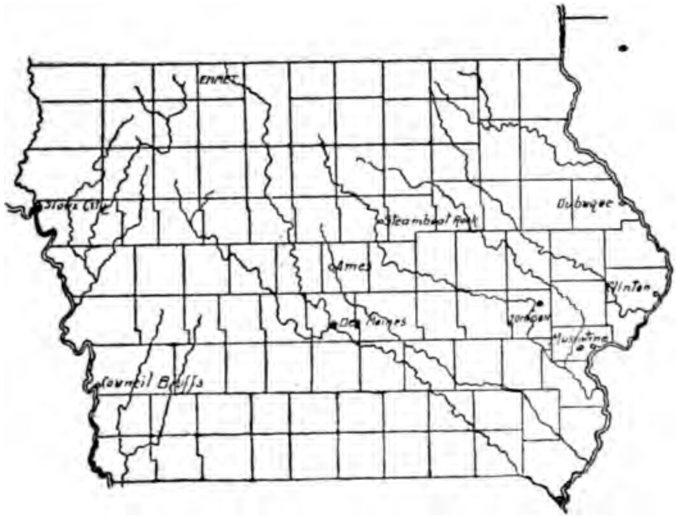
SOUTHWESTERN WISCONSIN: Bloomingdale—*Miss Pammel and Miss King.*



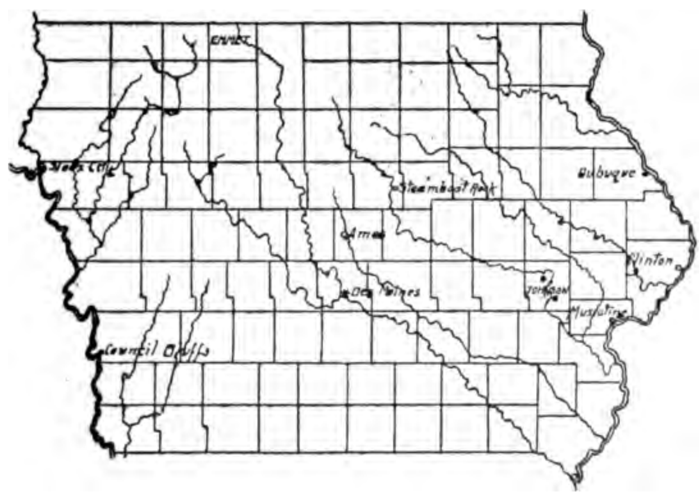
Distribution of *Botrychium Virginanum* Sw.



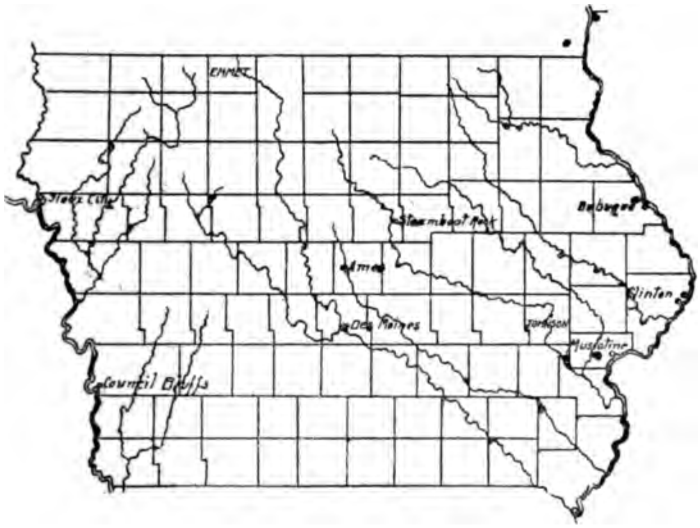
Distribution of *Lycopodium lucidulum* Michx.



Distribution of *Lycopodium complanatum* L.



Distribution of *Lycopodium clavatum* L.



Distribution of *Selaginella rupestris* Spring.

ORDER LYCOPODIACEÆ.

Lycopodium lucidulum Michx. Fl. Bor. Am. 2: 284. 1803.

This plant is rare in Iowa. The only reported localities are Muscatine and Steamboat Rock. This ought to be more frequent than *L. complanatum*. It was found on sandstone ledges near Steamboat Rock, the only Iowa specimen in our collection, though also reported by Shimek from Pine Creek, Muscatine county.

IOWA: Steamboat Rock—*Miss King.*

Lycopodium complanatum L. Sp. Pl. 1104. 1753.

There are only two reported in the state, Muscatine and Johnson counties. The Wisconsin specimen we found in hemlock woods with *Epigæa repens.*

SOUTHWESTERN WISCONSIN: Rockton—*Pammel.*

Prof. Shimek also reports *L. clavatum* from Johnson county, two localities.

ORDER SELAGINELLACEÆ.

Selaginella rupestris. Spring, Mart. Fl. Bras. 1²: 118. 1845.

There are no specimens in the collection from this state, but Prof. Shimek reports it from Muscatine, Dubuque and Lyon counties. It is not infrequent in pine woods and sandy barrens in Wisconsin.

SOUTHWESTERN WISCONSIN: La Crosse, "sandy barrens" —*Pammel.*

ORDER SALVINIACEÆ.

Azolla Caroliniana Willd Sp. Pl. 5: 541. 1810.

IOWA: Muscatine—*Reppert;* Lansing—*Miss King.*

PRELIMINARY NOTES ON THE FLORA OF W[illegible] ERN IOWA, ESPECIALLY FROM THE PHYSI[illegible] GRAPHICAL ECOLOGICAL STANDPOINT.

BY L. H. PAMMEL.

In this preliminary paper I shall consider brie[illegible] the ecological conditions of the flora, chiefly in t[illegible] ties of Harrison and Pottawattamie, with brief r[illegible] also to the flora of the adjoining counties. The w[illegible] spent some time in a study of the flora of weste[illegible] but much more work needs to be done before th[illegible] is entirely completed. The region is of great int[illegible] the botanical standpoint because this flora [illegible] plants which are common to the western flora.

Much work has been done along ecological li[illegible] ally that portion dealing with the different pl[illegible] tions, but we are only at the beginning of this line of work. This work was started by Warm[illegible] general treatise is classical. His work has gi[illegible] impetus to this study than any other investig[illegible] are also indebted to numerous other write[illegible] American. On this side of the Atlantic we [illegible] indebted to Prof. Conway MacMillan,* wh[illegible] admirable papers and his paper on the "D[illegible] Plants" along the shore at Lake of the Wo[illegible] what may be done.†

A contribution to the knowledge of the [illegible] eastern Minnesota.

Likewise the paper by Wheeler on a s[illegible] southeastern Minnesota.‡

*Minnesota Plant Life. Rept. of the Survey. Botanical Ser[illegible]
†Minn. Bot. Studies. 1: 949-1023. pl. 1897.
‡Minn. Bot. Studies. 4: 353. Pl. 21-27. 1901. separate.

The work of Clements and Pounds views the subject from a broad standpoint, giving also minute details of the plant formations.* In a more recent paper they have extended their work to more local conditions.† The chief center of this line of work in this country has been at the University of Chicago, where Cowles‡ and students of Prof. Coulter have devoted themselves assiduously to a study of the many intricate problems, problems by no means easy as shown by Cowles.

During the summer and fall two important papers on this subject have appeared, one by Dr. Bray|| on the ecological relations of the vegetation of western Texas, a region well worked by botanists and a choice field for botanical investigation. The richness of the flora became known through Wright, Lindheimer, Fendler, culminating in the large Flora of Western Texas by Coulter.§

While these men discussed the general floristic features of so interesting a region but little was known of the biological relations of these plants. The paper takes up (1) the climatic and edaphic factors, (2) physiography and geology, (3) plant formations.

The main divisions of plant formations are grouped under ·

a. Grass formations.
b. Woody formations.
c. Succulent formations.
d. Halophytic formations.

It is unnecessary in this connection to enter into details of the subdivisions of each, though important in interpreting the character of the plants and their relation to the general features of the flora.

Dr. Charles Mohr,** the well known botanist of Alabama, left as a monument to his many years of labor in Alabama

*Clements and Pounds. The Phytogeography of Nebraska. Gen. Sur. Nebr. 442. pl. 4, (2 ed.)

†Bessey, Pound and Clements. Report on the Recent Collections, Studies in the Vegetation of the State. 1: Univ. of Nebr. Bot. Surv. 5.

‡Cowles. The Ecological Relation of the Vegetation in the Sand-dunes of Lak[e Mich]igan. Bot. Gaz. 27: 95, 167, 281, 361. 1899.

||The ecological relations of the vegetation of western Texas. Bot. Gazette 195, 262, 24 f. 1901. Contr. Hull. Bot. Lab. 30.

§Botany of Western Texas. Contr. U. S. Nat. Herb. 2: 1891-4

**Plant Life of Alabama. An account of the distributio[n] ... adaptations of the flora of Alabama, together with a system[atic] ... growing in the state. Contr. U. S. Nat. Herb. U. S. Dept. o[f] ...

the most important contribution on local botany of our country. The author has discussed the ecological relations of this interesting flora. Each of the regions contains a discussion of the ecologic features. This great work may be compared with Willkonnu's der Iberischen Halbinsel.* Nor should I omit in this connection the interesting studies made by Kearney† on the plant covering of ocracoke island and Pieters‡ of Lake Erie in which interesting local conditions are described, as well as one by Lloyd F. Tracy on the Insular Flora of Mississippi and Louisiana.||

We should not however fail to recognize the fact that a number of investigators, especially those who concern themselves with the distribution of plants, discuss in a general way some of the physiographic conditions. In fact it was known to many of, these investigators that physiographic conditions played an important part in the distribution of plants; these floristic studies therefore contain notes of some importance on this subject. Some of these papers contain a true conception of this subject only lacking a classification. Warming's chief contribution was therefore an orderly arrangement and classification of these different formations. But Warming's classification was unsatisfactory in many respects, and we certainly are indebted to Dr. Cowles for having presented at least a classification which, though it may need some modifications, will prove satisfactory along broad lines. The complicated classifications presented by many writers rendered a study and proper conception of the subject nearly impossible. Classifications of this character should always be reduced to their simplest form, but even then in order to classify it may be necessary to study a large number of separate regions in order to bring the subject-matter together.

PHYSIOGRAPHY AND GEOLOGY.

The region which we are about to discuss is one that represents many interesting peculiarities. The soil con-

* Engler and Drude. Die Vegetation der Erde. I. Pflanzenverbreitung auf der Iberischen Halbinsel. 1896.

† Contr. U. S. Nat. Herb. 5: 261. *f. 33–50.*

‡ The plants of western Lake Erie with observations on their distribution. Bull. U S. Fish Com. 1901: 57-59 *pl. 11-20.* 1901.

|| Bull Torrey Bot. Club 28: 61. *pl. 8-11.*

ditions are so peculiar that they are well worth considering somewhat more in detail. Mr. W J McGee in a paper on the loess material of northeastern Iowa briefly discusses the question as follows:*

The macroscopic characters of the deposit are moderately constant:

"(1) It is commonly fine, homogeneous, free from pebbles or other adventitious matter, and either massive or so obscurely stratified that the bedding plains are inconspicuous; (2) it commonly contains unoxidized carbonate of lime in such quantity as to effervesce freely under acids; (3) it frequently contains nodules and minute ramifying tubules of carbonate of lime; (4) in many regions it contains abundant shells of land and fresh water mollusca; (5) is commonly so friable that it may be removed with a spade or impressed with the fingers, yet it resists weathering and erosion in a remarkable manner, standing for years in vertical faces and developing steeper erosion slopes than any other formation except the more obdurate clastic or crystalline rocks."

McGee states that it is a fallacy to regard the loess as identical in composition or that it is identical in genesis even in age.

As to its origin Chamberlain and Salisbury† find that in western Wisconsin and contiguous parts of Illinois and Iowa its composition varies in different localities with that of the associated drift and that composition and distribution point to glacial silt as the parent formation of the loess in the upper Mississippi valley. Prof. McGee in speaking of the plants of northeastern Iowa lays great stress upon the occurrence of forest trees upon this area. Now while it is true that the loess of the northeastern and eastern Iowa is abundantly covered with trees except in certain limited sections the loess of the Missouri deposits is more frequently devoid of trees, it is true that a part of this area is covered with good forest growth. In a paper

*The Pleistocene history of northeastern Iowa. Ann. Rept. U. S. Geological Survey 11: 291.

†Ann. Rep. U. S. Geol. Survey 6: 286 1885.

on the loess by Prof. B. Shimek.* "Is the Loess of Aqueous Origin?", he discusses the question of the loess, in which he comes to the conclusion.

"It seems evident that the loess materials originated largely or wholly in drift, and as the comparatively recent investigations by members of the Iowa geological survey have demonstrated the presence of several drift sheets in this state, and as Nebraska has at least two such sheets, an interesting problem is suggested to geologists, namely: the determination of the relation which the various deposits of loess bear to those drift sheets which during the deposition of the loess were found at the surface of adjacent regions. This would involve a careful comparison of the finer materials in the drift with loess, and the consideration of the probable or possible direction and means of transportation to the present location of the loess."

In another paper on the same subject Prof. B. Shimek[⊥] says:

"The loess-fauna, of Council Bluffs, is thus not wholly terrestrial, but with the exceptions noted, is almost identical with the modern upland fauna of the same regions. Surely no conditions of excessive moisture prevail in that region today.

"The amount of material carried by the winds need not have been so great as is sometimes assumed. The estimate made by the writer for the rate of deposition for eastern loess (1 mm. per year), and that made by Keyes for western loess (one-tenth to one-fourth of an inch) would be sufficient to form most of these deposits respectively in the 8,000 years, usually computed, since the recession of the glaziers.

"The objection made by Dr. Chamberlain that 'the eolian deposits are measured, not by the quantity of silt borne by the winds and lodged on the surface, but by the difference between such lodgment and the erosion of the surface,' is met, at least in part, by the theory offered, for it is a well-known fact that timbered areas, even when very rough and

* Proc. Io. Acad. Sci. 5: 32.
⊥ ... tribution of loess fossils. Proc. Io. Acad. Sci. 6: 98.

Figure 7. *Astragalus lotiflorus* on loess bluffs, Missouri Valley. Photographed by Miss C. M. King.

Figure 8 The loess bluffs in the distance; the Missouri River flood plain is a great prairie except here and there small willow groves consisting of the small *Salix interior* and *S. amygdaloides*, the latter a tree from a foot to ten feet in diameter; on the borders *Vernonia fasciculata*, *Boltonia asteroidea*; in the shallow water *Scirpus lacustris*, *Ranunculus multifidus*; *Helianthus Maximiliani* on high grounds. Photographed by L. H. Pammel.

with abundant slopes, are scarcely eroded by even the most violent precipitations of moisture."

Professor Udden's recent admirable report also bears on this question, and should not be overlooked by the student of loess-problems.

"No distinction can be made between the origin of eastern and western loess. The finer quality and lesser thickness of the former rather suggest that there had been more moisture (*i. e.*, a shorter dry period during each year) and, hence, less dust; that the winds were less violent, and that there were greater areas completely covered with vegetation, this resulting in the necessity of transporting dust much greater distances, which would therefore be finer."

CLIMATIC AND EDAPHIC FACTORS.

While the physiographic and geological formations have an important bearing on the distribution of plants there are certain other factors such as climate and the edaphic that must be taken into account when considering the distribution of plants. Mr. Nicholas Whitford* in a paper on "The Genetic Development of the forests of northern Michigan" considers the ecological factors into edaphic, atmospheric, hydrodynamic, and biotic. The hydrodynamic may play some part in the distribution of seeds, and the biotic determine the tension lines between forest and prairie, the atmospheric influence the soil so as to make it receptive for tree growth.

ALTITUDE. The altitude of the Missouri river basin is not far from 1,000 feet. It is somewhat less on the immediate shore lines of the Missouri and more than this towards the interior and northward. The region here considered lies between 39.5° and 43.5° north latitude.

The following altitudes are taken from reports of the Iowa Geological Survey† and Gannett's table of altitudes.

*Bot Gazette 31: 291.

†Bain, H. F. Geology of Plymouth county. Io. Geol. Surv. 8: 320.

Bain, H. F. Geology of Woodbury county. Io. Geol. Surv. 5.

Bain, H. F. Geology of Carroll county. Io. Geol. Surv. 9: 59.

TABLE OF ALTITUDES.

STATION.	ALTITUDE.	AUTHORITY.
Chatsworth, Big Sioux Valley	1,152	C. M. & St. P. Ry
Westfield, Big Sioux Valley	1,131	C. M. & St. P. Ry
Struble, Floyd Valley	1,271	S. C. & N. Ry.
Dalton, Floyd Valley	1,212	S. C. & N. Ry.
Merrill, Floyd Valley	1,167	I. C. Ry.
Sioux City, (low water) Missouri River	1,076	Mo. River Comm.
Sioux City, (reservoir) Missouri River	1,342	City Engineer.
Salix, Missouri River	1,092	S. C. & P. Ry.
Sargent's Bluff, Missouri River	1,103	S. C. & P. Ry.
Carroll, Tops of Hills	1,400	
Council Bluffs, Federal Building	989	
Hamburg, Missouri Valley		
Clarinda		
Cresco, Missouri Valley		
Missouri Valley, Missouri Valley		
Woodbine, Boyer Valley		

Temperature.—The region here considered naturally would not show very much variation in temperature except such coming within the limits of difference due to latitude. The northern portion, owing to its higher altitude and open prairie, is somewhat cooler than the more thickly wooded southwestern Iowa. It is a noticeable fact, however, that the thermal belts extend along the Missouri and that they can successfully grow certain varieties of apples and cherries that will not succeed further eastward on the same parallels of latitude. This is brought out quite strikingly in a paper by Mr. Greene.*

The following temperature records show these differences for Page county in southeastern Iowa, Sioux City in Woodbury county, and Council Bluffs in Pottawattamie county:

CLARINDA.

YEAR.	TEMPERATURE—DEGREES.						
1893	47.4	57.9	70.5	75.3	69.6	65.9	41.1
1894	53.3	62.1	73.5	76.3	77.6	66.4	51.0
1895	53.9	62.2	68.6	70.2	73.2	68.4	47.8
1896	54.3	63.8	68.4	73.7	73.8	61.5	49.8
1897	50.8	61.6	72.9	78.8	71.6	73.2	51.3
1898	51.8	62.2	75.0	80.2	80.6	72.6	52.4
Averages	51.9	61.6	71.5	75.8	74.4	68.0	49.9

*Rep. Iowa Hort. Soc. 1900: 55.

SIOUX CITY.

YEAR.	TEMPERATURE—DEGREES.						
93	44.6	57.0	72.0	75.0	70.7	66.0	45.0
94	51.6	62.4	72.0	76.0	75.2	65.7	49.2
95	57.0	62.0	68.0	72.4	72.6	67.7	47.8
96	52.0	64.4	70.0	72.4	71 8	58.4	41.2
97	47.6	59.1	68.4	76.2	68.2	71.7	46.8
98	49.6	59.5	70.9	73.3	72.5	65.2	47.8
Averages ..	50.4	60.7	70.2	74.2	71 8	65.8	46.4

COUNCIL BLUFFS FOR 1900.

	Date.	Maximum degrees.	Minimum degrees.	Date.
January	22	63	-8	25
February	11	47	-11	8
March	12	77	-4	16
April	26	81	26	10
May	11	91	32	2
June	6	98	50	1
July	6	101	55	16
August	17	96	60	25
September	5	96	38	16
October	4	89	29	16
November	3	77	10	20
December	17	60	0	31

Annual mean, 51.9 degrees.

SUNSHINE AND WIND.

Temperature is influenced to a considerable extent by the condition of the atmosphere. The following table kindly prepared by Mr. J. R. Sage of the Iowa State Weather and Crop Service shows the number of cloudy, partly cloudy, and clear days for year 1898, also recording the totals for the year 1900 for the same places.

MONTH.	CHARACTER OF THE DAYS.	Keokuk.	Sioux City.	Council Bluffs.	Clarinda.
January....	Clear days..........................	13	15	13	15
January....	Partly cloudy	4	4	3	4
January....	Cloudy......	14	12	15	12
February...	Clear days.........	12	10	8	15
February...	Partly cloudy.........................	4	11	11	8
February...	Cloudy.............................	12	7	9	5
March	Clear days..........................	1	11	10	15
March......	Partly cloudy	5	10	12	6
March......	Cloudy.....	15	10	9	10
April......	Clear days......	11	12	3	16
April......	Partly cloudy	10	8	18	7
April.......	Cloudy...............................	9	10	9	7
May........	Clear days..........................	7	6	4	12
May........	Partly cloudy	14	8	21	7
May..	Cloudy......	10	17	6	12
June.......	Clear days...........................	15	13	0	17
June.......	Partly cloudy	7	7	24	4
June.......	Cloudy............................ ..	8	10	6	9
July.......	Clear days....	20	16	*	18
July.......	Partly cloudy	6	8	*	10
July.......	Cloudy	5	7	*	3
August.....	Clear days.........	17	16	16	21
August....	Partly cloudy	4	12	12	7
August.....	Cloudy	10	3	3	3
September..	Clear days..........................	10	18	17	19
September..	Partly cloudy	13	2	6	6
September..	Cloudy	7	10	7	5
October ...	Clear days.........................	8	12	15	8
October	Partly cloudy	8	5	3	12
October	Cloudy	15	14	13	11
November..	Clear days...........	12	14	15	15
November..	Partly cloudy	12	6	6	8
November..	Cloudy	6	10	9	7
December..	Clear days..........	16	13	19	18
December..	Partly cloudy	6	10	3	8
December..	Cloudy............	9	8	9	5
	Total clear days	152	156	120	[illegible]
	Total partly cloudy days........	93	91	129	[illegible]
	Total cloudy days	120	118	95	[illegible]
	PREVAILING WINDS—	N.W.	N.W.	S.	N.[illegible]
	Total clear days.....	242	169	200	1[illegible]
	Partly cloudy days..........	31	86	74	1[illegible]
	Cloudy days................	92	110	91	90

Heat is an important factor in the development of plants. The plant zones of Humboldt were established by connecting the points having the same mean annual temperature. He called these isothermal lines. On this basis there were established the *Boreal*, *Austral* and the *Tropical*

* Not reported.

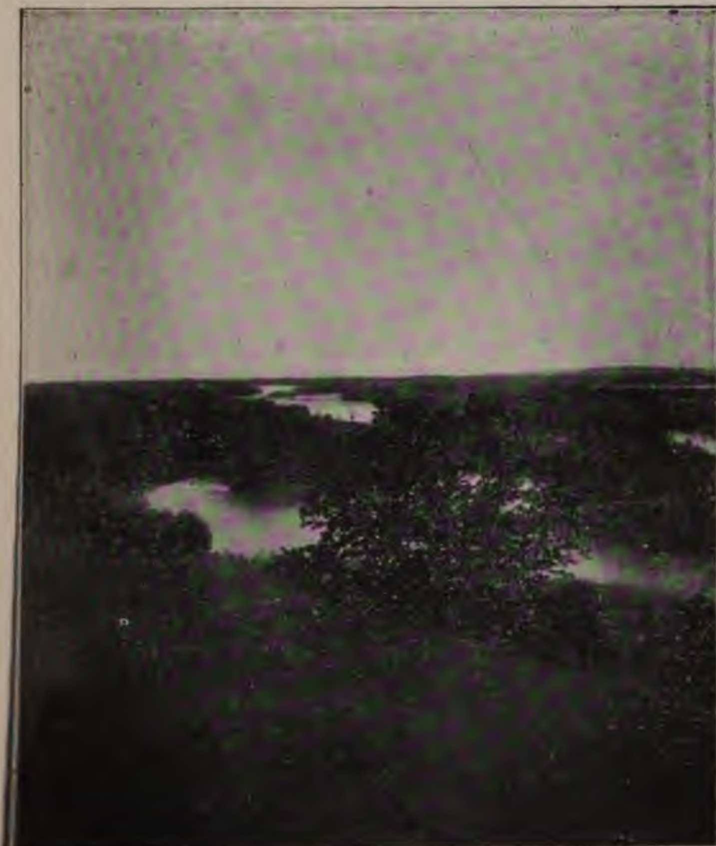


Figure 9. Mississippi River bottom above Clinton showing the heavily timbered woods and the wide flood plain. The timber consists mostly of *Acer saccharinum, Ulmus Americana, Fraxinus viridis, Betula nigra, Salix fluviatilis; Vernonia fasciculata* and *Boltonia asteroides* also here. Photographed by L. H. Pammel.

Figure 10. A densely wooded bank in one of the canyons along the Missouri River near Missouri Valley, Iowa. *Ribes gracile* in the foreground, *Prunus Virginiana* and other shrubs farther back; underneath these bushes *Dicentra cucullaria* and *Viola cucullata* grow in abundance. Photographed by L. H. Pammel.

ones. It was found, however, that zones established on sothermal lines did not express the true conditions, since wo points of the same mean annual temperature may low wide differences in the extremes of annual, monthly daily temperatures. It was found that life processes pend on these more than on the mean, hence some other sis must be established for the life zones.

Merriam established his life zones on another principle, mely, that it requires a definite amount of heat to complish the life* cycle of the plant from the time of rmination to maturity. That for a given species this is e same, being the sum of the mean daily temperatures ring the cycle of vegetation. This is the physiological nstant.

Dr. Merriam recognizes the following classification:

(1)	Boreal Region....................		Arctic or arctic alpine. Hudsonian zone. Canadian zone.
		Transition zone...	Alleghanian. Arid transition. Pacific coast transition.
(2)	Austral Region.	Upper austral zone	Carolinian area. Upper Sonoran.
		Lower austral zone	Austroriparian. Lower Sonoran.
(3)	Tropical Region.		

Alleghanian area. This area reaches its greatest develpment in this state along the Mississippi and reaches over the Missouri river extending further eastward in southestern Iowa, thence further north along the river. The he representative plants are:

Juniperus Virginiana (northward).	*Tilia Americana.*
Quercus macrocarpa.	*Sanguinaria Canadensis.*
Corylus Americana.	*Negundo aceroides.*
Rhus glabra.	*Ulmus Americana.*
Prunus Americana.	*Acer saccharinum.*
Dicenta cucullaria.	*Acer nigrum* (Des Moines basin.)
Solidago serotina (northward).	*Aster Novæ Angliæ* (northward).

Carolinian. This area reaches its greatest extension in utheastern Iowa, spreading northward to Dakota, with a w representatives. The representative plants are:

* Life Zones and Crop Zones of the United States. Div. Biol. Surv. U. S. Dept. Agrl. Yearbook U. S. Dept. of Agrl. 1897: 115. 1894: 208-214.

Gymmocladus Canadensis.	*Juglans nigra.*
Morus rubra.	*Rhamnus lanceolata.*
Nelumbo lutea.	*Vernonia Noveboracensis.*
Polygonum Pennsylvanicum.	*Polygonum dumetorum* var. *scandens.*
Martynia proboscidea.	*Eupatorium serotinum.*

Arid transition. This area reaches its greatest development along the immediate border of the Missouri river on the loess bluffs but extends eastward to the divide between the Mississippi and Missouri rivers in Carroll and Dickinson counties. Representative plants are as follows:

Cnicus canescens.	*Shepherdia argentea* (N).
Symphoricarpos occidentalis.	*Helianthus annuus.*
Yucca augustifolia.	*Helianthus Maximiliani.*
Petalostemon multiflorus.	*Gaura coccinea.*
Aplopappus spinulosus.	*Gaura parviflora.*
Grindelia squarrosa.	*Liatris pnnctata.*
Euphorbia marginata.	*Euphorbia heterophylla.*
Hosackia Purshiana.	*Lactuca pulchella.*
Erysimum asperum.	*Dalea laxiflora.*
Psoralea esculenta.	*Mentzelia ornata.*
Lygodesmia juncea.	*Soorobolus cuspidatus.*
Bouteloua oligostachya.	*Buchloe dactyloides* (N. W.).
Schedonnardus Texanus (N W.).	*Oxytropis Lambertii.*
Astragalus lotiflorus var. *brachypus.*	

It should be observed that the zonal boundaries of plants are not sharply marked, but that the different areas contain marked types of each of the areas. The main features of the flora is essentially prairie. The intermingling of western and eastern prairie types is most marked on the loess bluffs.

RAINFALL.

That moisture is an important factor in the development of plants cannot be questioned. The occurrence of strictly western plants within the border of Iowa must in part be attributed to the smaller amount of precipitation. The precipitation is given for the same points as the temperature.

SIOUX CITY.

Precipitation in Inches.

Year.	April.	May.	June.	July.	August.	September.	Annual.
1893	3.56	3.17	1.63	2.29	5.85	1.11	23.83
1894	2.79	1.91	2.74	1.81	1.68	0.73	18.79
1895	3.20	2.15	4.95	2.63	1.54	3.91	20.29
1896	6.16	6.39	2.94	5.54	0.86	2.09	30.77
1897	4.03	1.24	2.13	2.26	2.51	0.51	20.38
1898	1.37	4.69	6 61	2.78	3.10	0 95	22.91
Average	3.52	3.26	3.50	2.88	2.59	1.55	22.83

CLARINDA.

1893	3.11	3.17	4.12	8.84	6.22	2.38	33.27
1894	2.06	1.37	4.02	0.41	0.23	2.53	17.96
1895	2.82	2.99	8.33	6.44	4.64	0.95	30.79
1896	3.72	7.48	2.12	6.63	2.86	2.56	33.73
1897	6.00	2.01	4.04	2.63	2.53	1.55	26.32
1898	3.70	5.15	2.99	4.49	1.16	5.74	33.49
Average	3.57	3.70	4.27	4.91	2.94	2.62	29.26

KEOKUK.

1893	5.41	4.36	2.37	2.60	1.16	3.18	27.94
1894	2.75	3 06	2.95	0.37	0.51	4.86	25.20
1895	3.38	3.45	2.61	5.46	2.28	2.67	29.42
1896	2.35	4.40	2.18	8.01	3.90	9.44	36.77
1897	3.34	1.86	5.43	6.75	0.65	0.64	33.14
1898	4.80	6.70	4 77	3.06	6.92	8.07	52.48
Average	3.67	3.97	3.38	4.38	2.57	4.81	34.16

COUNCIL BLUFFS.

The precipitation for Council Bluffs for 1900 was 31.87 inches.

It will be seen from the above tables that the average rainfall for a period of six years in the northern section along the Missouri river at Sioux City was 22.8 inches, at Clarinda in Page county, 29.26 inches. Compare this with the precipitation in Keokuk in the southeastern part of the state the precipitation for the same period was 34.16 inches. Now compare this with the mean annual temperature for the same regions: Keokuk, 52.2°F., Sioux City, 46.4°F., Clarinda, 49.9°F. The greater number

of clear days or partly cloudy days in western Iowa is shown in the table prepared for the year 1898 by Mr. J. R. Sage and which has been given under the heading sunshine and wind. It is not as marked as one would expect—

PHENOLOGICAL DATA FOR WESTERN IOWA.

Crescent. May 3, 1901.
Sisyrinchium angustifolia.
Ellisia nyctelea.
Staphylea trifolia.
April 27.
Prunus Americana.
Viola palmata var. *cucullata.*
Viola pedatifida.
April 28
Lithospermum canescens.
Lithospermum angustifolium.
Cratægus mollis.
Fragaria Virginiana.
Sisymbrium canescens.
May 4.
Castillea sessifolia.
Astragalus caryocarpus.
Pyrus malus.
May 5.
Prunus Virginiana.

Missouri Valley, May 19, 1901.
Ceanothus ovatus.
Anemone Pennsylvanica.
Senecio aureus
May 20.
Erigeron annuus.
Phlox pilosa.
Utricularia vulgaris.
June 18.
Echinacea angustifolia.
Asclepias tuberosa.
Asclepias syriaca.
June 20.
Cacalia tuberosa.
Lilium Philadelphicum.

Convolvulus sepium.

Mr. John J. Thornber* prepared a phenological record of some plants found in Nebraska City, Nebraska, which is south of Council Bluffs, but typical of the loess region.

April 27, 1900.
Viola pedatifida
Lithospermum canescens
May 4, 1900.
Carex festucaceæ
May 7, 1899.
Comandra umbellata
May 10, 1900.
Ceanothus ovatus
May 20, 1900.
Eleocharis palustris
Juncus tenuis
May 28, 1900.
Chenopodium album
Eatonia obtusata

June 7, 1901.
Coreopsis palmata
Cornus asperifolia
June 21, 1900.
Helianthus annuus
June 22, 1900.
Lilium Canadense
Desmodium Illinoense
July 15, 1900.
Scutellaria lateriflora
August 4, 1900.
Solidago Canadensis
August 30, 1900.
Gentiana puberula
September 17, 1900.
Aster azureum

* The prairie grass formation in Region I. Bot. Survey Nebraska. 5: 187.

These records may be compared with the phenological notes for Ames and Armstrong. The former in central Iowa and the latter in north central Iowa.

AMES.	ARMSTRONG.
May .	June 18.
Crataegus mollis	*Salsola Kali* var. *Tragus*
May 7.	*Acerates viridiflora*
Aquilegia Canadensis	*Asclepias tuberosa*
Prunus Virginiana	*Linum usitatissimum*
Fragaria Virginiana	*Symphoricarpos occidentalis*
	Lathyrus venosus
	Rudbeckia hirta

Unfortunately there are but few representatives of the same species from these different localities. The *Cratægus mollis*, *Aquilegia Canadensis*, *Prunus Virginiana* and *Fragaria Virginiana* are nearly a week later in Ames than in Missouri Valley and Crescent. These points are slightly south of Ames, but not enough to materially influence the period of flowering. The loess region along the Missouri river is distinctly warmer than central Iowa, which is distinctly influenced by the cold and impervious soil. The impervious nature of the soil is shown by the many small lakes and ponds in central Iowa, but nearly wanting in western Iowa.

While plants are called into activity sooner in Keokuk than in Sioux City, they mature in a relatively shorter period of time in the latter place owing to clearness of the sky, and the drier weather.

WIND.

The wind is another most important factor in the development of the plant life in that region. The tendency of the wind is to increase transpiration so that plants with tender foliage are wanting or occur in the canons or wooded ravines. The wind has such an erosive action that stones may become polished as in the boulder here shown resting on the drift. The writer has seen clouds of dust, carried high in the air, last for several days. Such dust settling on plants cannot but be injurious in checking the

life processes of the plant. A smooth leaf soon has its stomata filled with dust. On the other hand the hairs on leaves serve to hold this dust.

Protected plants. Such plants as *Applopappus spinulosus, Oxytropis Lambertii, Lithospermum canescens, L. angustifolium, Psoralea argophylla, Gaura coccinea, Dalea alopecuroides* are well protected from the driving winds of summer and fall.

Of the plants needing much moisture and commonly growing in open woods of the eastern section of the state but rare or wanting in western Iowa, mention may be made of the following:

Podophyullum peltatum.	*Fragaria vesca.*
Heracleum lanatum (rare).	*Mertensia Virginica.*
Caulophyllum thalictroides (rare).	*Lobelia cardinalis.*
Solidago latifolia.	*Lobelia inflata.*
Dodecatheon media.	*Hydrophyllum appendiculatum.*

Deep rooted plants. An equally instructive list of plants may be added to show how some plants have protected themselves from the injurious influences of wind and drouth by producing deep roots. These roots are sometimes several feet long.

Dalea laxiflora.	*Oxyttropis Lambertii.*
Psoralea esculenta.	*Astragalus lotiflorus* var. *brachypus.*
Lygodesmia juncea.	*Cnicus canescens.*
Lactuca pulchella.	*Gaura coccinea.*
Aplopappus spinulosus.	*Sporobolus cuspidatus.*
Yucca angustifolia.	*Asclepias tuberosa.*

Transpiration reduced. As a protection against transpiration the leaves of many plants are hairy or reduced in size. Of the hairy leaved plants we may mention the following:

Convolvulus sepium.	*Oxyttropis Lambertii.*
Asclepias verticillata.	*Castilleia sessiflora.*
Cnicus canescens.	*Gaura parviflora.*
Cnicus Iowensis.	*Salvia lanceolata.*
Aplopappus spinulosus.	*Plantago Patagonia* var. *gnapalioides*
Euphorbia marginata.	*Asclepias speciosa.*
Achillea millefolium.	

Xerophytic grasses. The Xerophytic grasses of the loess mounds are especially characterized by their reduction of

leaf surface or the leaves roll in when the transpiration is too great. Of these we may enumerate:

Sporobolus cuspidatus.	*Stipa spartea.*
Calamovilfa longifolia.	*Poa compressa.*
Andropogon scoparius.	*Poa pratensis.*
Bouteloua racemosa.	*Agropyron occidentale.*
Bouteloua oligostachya.	*Elymus Canadensis.*

It must not be assumed that hydrophytic and mesophytic plants are wanting, they are numerous as the writer's list* indicates. Such species as *Leersia oryzoides*, and *Leersia Virginica*, *Ultricularia vulgaris*, *Potamogeton*, *Sagittaria*, *Ranunculus multifidus* are well known representatives of stagnant pools and slow running streams. *Cystopteris fragilis*, *Festuca nutans*, *Bromus purgans*, *Eupatorium ageratoides* are well known mesophytic representatives of woods.

PLANT FORMATIONS.

In this paper I have adopted the excellent classification of Cowles† as well as some valuable suggestions from the paper by Pound and Clements.‡

In the paper by Cowles two general groups are made.

I. *Inland group:*
   1. River.
   2. Swamp.
   3. Upland.

II. *Coastal:*
   1. Lake bluff.
   2. Dune.

The Pounds and Clements Classification for Nebraska is as follows:

I. Wooded—bluff and meadow land region.
II. Prairie region.
III. Sandhill region.
IV. Foothill region.

The region considered in this paper would be embraced in the wooded bluff and meadow land region.

* L. H. Pammel. Notes on the Flora of Western Iowa. Proc. Io. Acad. of Sci. 3: 106-135. Contr. Bot. Dept. Io. Coll. Agrl. and Mech. Arts. 1.

† Bot. Gazette 31: 73, 145.

‡ The Phytogeography of Nebraska. General Survey. Univ. Neb. Bot. Survey of Neb. 1.

INLAND GROUP.

1. RIVER SERIES.

1. *The Missouri Floodplain.*--It is not necessary in this connection to discuss the early history of the formation of this flood plain* as this follows the same general laws so well set forth by Cowles.

This is the youngest of the series, and near the shore of the river is subject to frequent changes. The broad level plain is from eight to twelve miles wide, varying but little in the consistency of the soil or the vegetation from Council Bluffs to Sioux City. Sparsely timbered except near the shore lines of older streams, the bayous of more recent formation or near the basis of the bluffs. In the earlier stages of the development of this flood plain as it exists today. The plants are mainly hydrophytic. Among the lower plants, *Spirogyra and Zygnema.* Of the flowering plants:

Potamogeton natans.	*Lemna major.*
Ranunculus multifidus.	*Utricularia vulgaris.*
Scirpus lacustris.	*Scirpus palustris.*
Rumex verticillatus.	

SWAMPS.

Owing to the wide flood plain the waters of the Missouri have never had a very rapid current. It has frequently shifted its course. When sufficient age has been obtained mesophytic plants appear. One of the most conspicuous of these is the *Phalaris arundinacea*, one of the vernal grasses, which blooms and produces ripe fruit before the dry season. During its early growth it is of hydrophytic habit. It is thus semi-mesophytic. *Ranunculus multifidus* is also a frequent inhabitant of these slow running streams, and during its early existence only produces finely dissected leaves freely floating in the water, but as the stream dries up the plants at once develop smaller round, reniform, coarsely dissected leaves. These plants root in the mud.

* l. c. 98.

Other plants of like character also appear under such conditions.

Sagittaria variabilis.	*Alismago Plantago* var. *Americana.*
Iris versicolor.	*Carex* Sps.
Typha latifolia.	

At least the *Iris*, *Typha*, and *Scirpus lacustris* may occur in places that during later summer are entirely dry. These plants on the one hand are deep rooted as in Scirpus or have thick root-stocks as in Iris. When not covered by plants the ground often becomes very hard. On the disappearance of the early vernal plants, the ground soon becomes covered with a thick growth of late summer and autumn plants. The ground is thickly covered towards the center and margins of the bayous. Of spring and early summer plants under the shade of *Salix amygdaloides*, *Polygonum acre* is a dominant plant. The *Boltonia asteroides* isone of the most conspicuous of later plants, and along with it *Vernonia fasciculata* which,however,is more mesophytic than *Baldwinia*. Conspicuous later vernal plants here are *Veronica peregrina*, and *Erigeron annuus*. The bayous with the continual deposit of alluvium sand aud dirt and the decay of the hydrophytic and mesophytic plants or other material washed in gradually becomes filled up, so that a change in the character of plants occurs. The *Salix amygdaloides* is the only tree found in these situations. When these slow-running streams are filled up with vegetable detritus and inorganic material they die and the *alluvial prairie* appears. In this alluvial flood plain many plants are common to those of the upland prairies. The alluvial prairie is rich in grasses although there are but few species. Fresh water cord grass, *Spartina cynosuroides* is conspicuous. The rhizomes of the grass are often two feet long. This is essential for the plant as it prevents washing the plant away. There are times when a good part of this flood plain has been under water for several days at a time. Here, too, *Rumex altissimus* is a dominant type.

Vernonia fasciculata.	*Helianthus maximiliani.*
Of the annuals.	
Helianthus annuus.	*Panicum crus-galli.*
Euphorbia maculata.	*Euphorbia serpeus.*

The Missouri carries large amounts of finely suspended matter and the throwing up of this along the shore lines causes the formation of the higher places in the flood plain.

The most prominent of the grasses here is *Andropogon provincialis*. *Panicum virgatum* is also common. *Helianthus maximiliani* also occurs on the borders of the meadows.

Species of the alluvial region of the Missouri and their origin.

Ranunculus septentrionalis (E.).
Ranunculus abortivus (E.).
Nasturtium terrestre (E.).
Viola palmata var. *cucullata* (E.).
Crotalaria sagittalis (E.).
Clycyrrhiza lepidota (W.).
Strophostyles angulosa (E. & S.).
Potentilla Norvegica var. *millegrana* (W.).
Crypotolænia Canadensis (E.).
Cicuta maculata (E. & N.).
Vernonia fasciculata (E. & S.).
Solidago serotina (E.)
Boltonia aeteroides (E. & S.).
Aster ercoides (E. & S.).
Erigeron Philadelphicus (E.)
Iva xanthiifolia (W.).
Ambrosia trifida (E).
Xanthium Canadense (E. & S.).
Helianthus annuus (W.).
Helianthus grosse-serratus (W.).
Helianthus maximiliani (W.).
Bidens chrysanthemoides (E.)
Scirpus lacustris (Cos.).
Panicum virgatum (W. & E.).
Mimulus ringens (E. & S.).
Verbena hastatata (E. & S.).
Teucrium canadense (E.).
Acnida tuberculata (S.).
Amarantus alba (W.).
Rumex verticillatus (E.).
Polygonum ramosissimum (S.).
Polygonum Virginianum (E.).
Polygonum lapathifolium var. *incarnatum* (S.).
Polygonum Muhlenbergii (E. & S.).
Polygonum Pennsylvanicum (E. & S).
Shepherdia argentea (W.).
Euphorbia marginata (W.).
Euphorbia serpens (W. & S.).
Euphorbia glyptosperma (S. & W.).
Euphorbia Geyeri (W.)
Juncus tenuis (Cos.).
Typha latifolia (Cos.).
Sparganium eurycarpum (E & W.).
Alisma Plantago var. *Americana* (E)
Echinodorus rostratus (S. & W.).
Cyperus diandrus (E. & W.).
Andropogon furcatus (E. & W.).
Spartina cynosuroides E. & W.).

OLDER FLOOD PLAINS.

During glacial times the Missouri carried large volumes of water and much of the present flood plain was a huge stream of water, being augmented by several streams of considerale size like the Boyer, Floyd, and Big Sioux, with inland lakes some of which like Lake Manawah near Council Bluffs still exist, these lakes being formed by the washing of sediment at the mouth of the streams, by the deposition of fine silt. The water of the streams flowing through these flood plains is so slow that the backwater

Figure 16. Hydrophytic vegetation in the flood plain of the Missouri river near Honey creek. *Phragmites communis* and *Phalaris arundinacea*.

Figure 17. Alluvial bottoms of the Missouri. The sluggish streams with hydrophytic vegetation and the higher shore lines with such mesophytic plants as *Spartina cynosuroides*, *Helianthus Maximiliani*.

from the Missouri fills up the nearly level plain forming the lakes in which an abundant hydrophytic vegetation occurs. As these ancient lakes became gradually filled with organic matter, herbaceous plants similar to those of the Missouri flood plain appeared. The continued increase of organic matter made a soil more suitable for prairie plants of a different character. Of the vernal plants we may note the *Ranunculus septentrionalis*, *Senecio aureus* var. *Balsamite*, the latter forming distinctive features of these meadows, frequently producing masses of yellow flowers. The *Anemone Pennsylvanica* also forms solid masses. *Thalictrum purpurascens*, *Heuchera villosa*, *Asclepias syriaca*, *Silphium laciniatum*. These form great masses in the moister places. *Phlox pilosa* grows abundantly in the prairie meadows and is distinctively a prairie mesophytic plant, like *Poa pratensis*, *Helianthus grosse-serratus*. Of the younger formation distinctly hydrophytic we may mention

Rumex verticillatus.	*Glyceria fluitans.*
Phalaris arundinacea.	*Typha latifolia.*

The Boyer valley is marked by its prairie-like meadows intersected by very small ravines. The deposition of humus and considerable moisture in the soil prevents the rapid desintegration of organic matter, hence unsuited for the growth of trees and shrubs, but well adapted for species of *Carex*, *Elymus robustus*, *Phlox pilosa*, *Anemone Pennsylvanica* and *Senecio aureus*.

Towards the approach of the bluff formation on either side of the valley the drainage is more perfect, and tree and shrub life begins. Unlike the younger flood plain of the Missouri a narrow zone of forest growth skirts the Boyer. This forest area is not making much encroachment upon the prairie flood plain.

The soil along the stream is of much more recent formation than the prairie flood plains. To the gradual sloping banks there is added from year to year more black alluvial deposit. At first such plants as *Eragrostis reptans*, *Mimulus ringens*, *Polygonum acre*. Of the later autumn plants to appear here are *Helianthus grosse-serratus* and

Ambrosia trifida. The *Ambrosia trifida* being the immediate foreunner of small shrubs and trees.

The drainage along the stream is naturally more perfect than the soil away from the flood plain, the soil is better areated, hence trees can grow here. One of the first woody plants to appear is *Salix nigra* which overhangs the streams, *Salix amygdaloides* is also an early tree replaced later by *Negundo aceroides, Ulmus americanas, Populus monilifera* and *Fraxinus viridis.* Of the woody climbers the following may be mentioned.

Vitis riparia.	*Ampelopsis quinquefolia.*
Menispermum canadense.	*Rhus toxicodendron.*

of the herbaceous climbers the following appear in these young forests

Echinocystis lobata.	*Humulus lupulus.*

and shade loving plants like

Impatiens pallida.	*Coreopsis connatus.*
Bidens frondosa.	*Urtica gracilis.*

UPLAND.

THE RAVINE.

Owing to the peculiar loess formation in the Missouri valley region very few ravines in their younger stages can be seen, at least not in the west slope of the hills. It is only through the removal of loess material for manufacturing or grading that these embryonic ravines occur. Where such are found very little vegetation occurs. The vertical faces of the bluffs are in many cases one hundred feet high. On the bare faces one sometimes finds *Rosa blanda* var. *Arkansana and Lygodesmia juncea* deeply rooted in the soil. Very few land slides occur except where there is a considerable growth of herbaceous plants and the formation is underlaid by a sheet of water. At the base of these hills plants like *Gaura coccinea, Sporobolus cuspidatus, Lactuca pulchella* occur. The characteristic plants of the ravine beginning at the base are as follows:

Populus monilifera, *Salix humulis*, *Tilia Americana*, *Ulmus Americana*, *Fraxinus pubescens*, *Celtis occidentalis*, *Prunus Virginiana*, *Ribes gracile*, *Celastrus scandens*, *Rhus glabra*, *Rosa blanda* var. *Arkansana*, *Ulmus fulva*, *Quercus macrocarpa*, *Crataegus mollis*, *Populus monilsfera*, *Ostrya Virginica*, *Vitis riparia*, *Ampelopsis quinquefolia*.

Near the edges towards the top of the ravine,

Salix humilis, *Amorpha canescens*, *Salix amygdaloides*, *Symphoricarpos occidentalis*.

The *Symphoricarpos occidentalis* is the most abundant shrub in clearings, and on the hills is one of the most important plants in preparing the soil for a mesophytic forest. It remains as an undergrowth in the forest till the trees have attained an age of ten to fifteen years. It is abundant in all open clearings in the woods. This plant takes the place of *Corylus Americana* to a large extent in preparing the soil for a forest growth. *Corylus Americana* is rather a rare shrub. The *Rhus glabra* is nearly as important as *Symphoricarpos*. From the ravine the mesophytic flora extends to the slopes of hills, especially on the east and north slopes. The more important mesophytic herbaceous plants in the ravines are—

Dicentra cucullaria, *Eupatorium ageratoides*, *Lophanthus scrophulariæfolias* *Viola palmata* var. *cucullata*. *Parietaria Pennsvlvanica*, *Teucrium Canadense*, *Viola pubescens*,

As the ravines become older with a good covered humus and sufficient shade, the following plants are abundant:

Smilacina stellata, *Viola palmata* var. *cucullata*, *Aquilegia Canadensis*, Mosses like *Hypnum* and *Bryum*. *Sanicula Marylandica* *Hydrophyllum Virginicum*, *Cystopteris fragilis*, *Bromus purgans*, *Aster sagittifolius*. *Viola pubescens*, *Vicia Americana*, *Arabis hirsuta* *Eupatorium ageratoides*. *Ranunculus abortivus*, *Phlox divaricata*, *Smilax herbacea*, *Laportea Canadensis*,

The older ravines with a truly mesophytic flora contains a curious assemblage of southern plants that in the Missis-

sippi basin occur in the second or older alluvial flood plain, namely,

Morus rubra,
Juglans nigra,
Ulmus Americana.
Gymnocladus Canadensis,
Celtis occidentalis,

These plants occur at an altitude of nearly one hundred feet above the flood plain of the Missouri. The same species also occur on the western slope of the hills where sufficient age has been attained. Their occurrence under these conditions is due to lines of least tension. In the Mississippi basin and its tributaries such places would be occupied by—

Acer nigrum.
Juglans cinerea.
Quercus alba.
Quercus rubra.
Quercus tinctoria.
Cratægus species.

When we compare the trees we find but few prominent species of western Iowa that occupy the uplands of eastern Iowa, namely, *Crataegus mollis Quercus macrocarpa Q. rubra*, *Ulmus fulva* and a few others It seems to be a general law that closely related species generally have different habitats. *Juglans cinerea* along the Mississippi occupies the higher stony hills and this is more and more evident as the region of its greatest prominence is reached. It is easy therefore for *Juglans nigra* and its other south ern types to become important ravine and bluff plants along the Missouri.

Towards the east the xerophytic area becomes increasingly less, the ravines being filled to a considerable extent. These older ravines contain larger amounts of humus. These soils being well aerated permit decomposition and nitrification much more readily than in older soils, hence the appearance here of such mesophytic plants as

Cystopieris fragilis.
Dicentra cucullaria.
Smilacina racemosa.
Viola pubescens.
Uvularia grandiflora.
Amphicarpæa monoica.

These basins filled with humus also are more subject to washing owing to changes brought about by cultivation at the base of a ravine or the making of roads. These banks contain no plants though there is enough moisture present.

Figure 11. Loess resting on drift; northwestern Iowa. Herbaceous plants, like *Andropogon scoparius*, *Lygodesuria juncea*, &c. (From Vol. X, Iowa Geol. Surv.)

Figure 12. Loess slopes of the upland region, Plymouth county. The borders of the slopes are covered with *Andropogon provincialis*, *Helianthus maximiliani*. (From Vol. VIII, Iowa Geol. Surv.)

Figure 13. Loess over drift in Plymouth county. *Cleone integrifolia*, *Grendelia squamosa* and other composite with grasses like *Sporobolus cuspidata* cover the loess soil. (From Vol. VIII, Iowa Geol. Surv.)

Plants cannot anchor themselves because the soil is subject to washing. It is only when the washing has proceeded far enough to cause a considerable fill and a young alluvium forms that plants like the following appear:

Salix nigra.	*Salix amygdaloides.*
Coreopsis palmata.	*Bidens frondosa.*

We have in this region an excellent illustration of a mesophytic flora well established on the crest of hills. Nearly all of the eastern slopes of the hills and the very tops, east of the main line of bluffs, or those facing the principal streams are covered with a mesophytic vegetation which does not differ essentially from those of the older ravines.

GRASSY HILLS.

The loess mounds though made of a tenacious clay show no springs or running water anywhere except in the wooded canons at the base of the hills. The vegetation from early spring to fall is a succession of bloom, beginning with such plants as

Anemone patens var. *Nuttalliana*,	*Oxytropis Lambertii*,
Castilleia sessiliflora,	*Lithospermum canescens.*
Lithospermum angustifolium.	

Another common plant over the hillside is *Comandra umbellata.* Three weeks later the most conspicuous plant over the loess mound is *Symphoricarpos occidentalis*, which is most abundant near the timber line, encroaching upon the mounds. The *Symphoricarpos* is a forerunner of shrubs and trees at the edge of the loess mounds. Along with it, frequently in great abundance, is the *Verbena stricta* and the *Psoralea argophylla*, the latter with long roots. The *Lygodesmia juncea*, a typical xerophytic plant, is extremely common, occurring not only in the vertical clay banks but over the entire mound.

Near the tops of the mounds *Aplopappus spinulosus* forms broad masses. Quite widely distributed over these loess mounds we have the *Dalea laxiflora* and the *D. alopecuroides*, the former, with roots several feet long,

Figure 14. A heavily wooded ravine in the loess region. The chief types are *Prunus Virginiana*, *Ribes gracile*, *Ulmus fulva*, *U. Americana*, *Quercus macrocarpa* and occasionally *Morus rubra*. (From Vol. V, Iowa Geol. Surv.)

is particularly well adapted to xerophytic conditions, the small teretish leaves make it admirably fitted for the conditions existing upon the mounds. Along with it we find the *Petalostemon multiflorus*, both belonging to the typical plants of the plains of Nebraska and Colorado.

Of the early composite flowering plants upon the loess mounds the *Echinacea angustifolia* and *Rudbeckia hirta* are more or less common over the entire loess mounds. The *Heliopsis scabra* is common on the borders along with the *Symphoricarpos*, *Ceanothus* and *Verbena*.

Solidago Missouriensis,	*Dysoides chrysanthemoides*,
Achillea millefolium,	*Helianthus Maximiliani*,
Solidago rupestris,	*Grindelia squarrosa*,
Aster sericeus,	*Aster multiflorus*,
Antennaria plantaginifolia,	*Ambrosia psilostachya*,
Silene antirrhina,	*Helianthus rigidus*,
Asclepias verticillata,	*Oxybaphus hirsutus*,
Oxybaphus angustifolius,	*Salvia lanceolata*,
Gerardia aspera,	*Gerardia tenuiflora*,

are some of the common types found over the entire loess mounds. The *Liatris punctata* with its deep, straight roots enables the plant to be adapted to the drouthy conditions which frequently prevail in that region. The *Yucca angustifolia*, common in sections of Nebraska, the Dakotas and Kansas, is a rare plant in this region, although becoming more common northward in the vicinity of Sioux City. It is confined to the steep banks, well up near the summits of the mounds.

The mesophytic flora is gradually encroaching upon the xerophytic, and as important forerunners for the mesophytic vegetation several of the shrubs like *Symphoricarpos* play a conspicuous part. Eastward in northeastern and central Iowa the *Corylus Americana* is the chief forerunner for the mesophytic flora. In the Missouri valley the *Symphoricarpos* is the chief factor in changing the character of the vegetation.

The amount of precipitation collected for a series of years indicates that this region is much drier than in the drainage area east of the Missouri river basin.

PARTIAL LIST OF THE PLANTS OF THE LOESS BLUFFS AND THEIR ORIGIN.

Aplopappus spinulosus (W).
Lygodesmia juncea (W).
Vernonia Noveboracensis (S).
Eupatorium serotinum (S).
Kuhnia eupatoroides (E).
Liatris punctata (W).
Liatris scariosa (E).
Grindelia squarrosa (W).
Solidago speciosa (E).
Solidago rupestris (W).
Solidago rigida (E).
Aster oblongifolius (S).
Aster sericeus (E).
Aster multiflorus (E).
Antennaria plantaginifolia (E).
Silphium laciniatum (E & S).
Iva xanthiifolia (W).
Ambrosia psilostachya.
Echinacea angustifolia (E & S).
Rudbeckia hirta (W).
Lepachys pinnata (W).
Helianthus petiolaris (W).
Helianthus Maximiliani (W).
Coreopsis palmata.
Dysodia chrysanthemoides (W).
Cnicus canescens (W)
Cleome integrifolia (W).
Callirhoe involucrata (W).
Linum rigidum (W).
Trifolium stoloniferum (W).
Dalea laxiflora (W).
Solidago Missouriensis (W).
Asclepias tuberosa.
Monarda fistulosa.
Psoralea argophylla (W).
Sisymbrium canescens.
Oxalis corniculata (E).
Petalostemon violaceus (W).
Oxytropis Lambertii (W).
Cassia Chamæcrista (W & S).
Symphoricarpos occidentalis (W).
Erigeron strigosus (E & W).
Helianthus rigidus (W).
Troximon cuspidatum (W).
Taraxicum officinale (Cos).
Oxybaphus hirsutus (W).
Euphorbia maculata.
Lactuca pulchella (W).
Lobelia spicata (E).
Asclepias verticillata (western form).
Acerates viridiflora.
Phlox pilosa (E).
Lithospermum canescens (E).
Lithospermum angustifolium (E).
Pentstemon grandiflorus (E).
Castilleia sessiliflora.
Verbena stricta (W).
Hedeoma hispida (W).
Salvia lanceolata (W).
Scutellaria parvula (W).
Oxybaphus angustifolius (W).
Polygonum ramosissimum (S).
Euphorbia marginata (W).
Euphorbia corollata (E).
Salix humilis (E).
Yucca angustifolia (W).
Zygadenus elegans (W).
Sporobolus cuspidatus (W).
Elymus robustus (W).
Delphinium azureum (W).
Corydalis aurea var. *occidentalis* (W).
Erysimum asperum (W).
Viola pedata (W).
Linum sulcatum (W).
Ceanothus ovatus (W).
Hosackia Purshiana (W).
Petalosteum multiflorus (W).
Stipa spartea (W).
Amorpha canescens (W).
Anemone cylindrica (W & E).
Oxalis violacea (E).
Rhus glabra (E).
Astragalus carycocarpos (W).
Glycyrrhiza lepidota (W).
Potentilla arguta (E & W).
Houstonia angustifolia (E).
Helianthus annuus (W).
Achillea millefolium (Cos).
Convolvulus sepium, hairy form (W).
Rumex acetosella (Cos).
Euphorbia dictyosperma.
Euphorbia Geyeri (W).
Poa pratensis (Cos).

Euphorbia hexagona.
Euphorbia heterophylla.
Poa compressa (Eu).
Panicum Wilcoxianum (W).
Andropogon scoparius (W).
Calamovilfu longifolia.
Panicum capillare (E & W).
Bouteloua racemosa (E & W).
Panicum virgatum (W).
Sporobolus cryptandrous (E & W).

WOODBINE BLUFF FLORA.

It is interesting in this connection to compare the flora of the loess bluffs with that occurring at Woodbine. The region here is essentially the same as that at Woodbine excepting that the loess is somewhat diminished and the bluffs immediately encroaching upon the broad valley of the Boyer are more or less wooded. It is a noticeable fact here that of the strictly western species comparatively few of them are represented at Woodbine. On the grass covered bluffs the following are some of the more important of the plants. Of the early grasses we may mention—

Stipa spartea,
Poa pratensis,
Poa compressa,
Panicum Scribnerianum.

Of the early vernal plants—

Sisyrinchium angustifolium,
Viola palmata var. *cucullata*,
Oxalis violacea,
Sisymbrium canescens,
Achillea millefolium,
Lithospermum angustifolium,
Astragalus carycocarpus.
Hypoxis erecta,
Viola pedatifida,
Corydalis aurea var. *occidentalis*,
Antennaria plantaginifolia,
Lithospermum canescens,
Castillea sessiliflora.

Of the later blooming plants we may mention as especially prominent

Delphinium azureum,
Polytænia Nuttallii,
Silene antirrhina,
Lobelia spicata.
Echinacea angustifolia,
Phlox pilosa,
Erigeron annuus,
Rumex acetosella,
Erigeron strigosus.

especially the latter, which is extremely common.

Of the late June and July plants we may mention especially

Monarda fistulosa,
Psoralea argophylla,
Asclepias verticillata,
Heliopsis scabra,
Anemone cylindrica,
Lepachys pinnata,

Figure 14. A heavily wooded ravine in the loess region. The chief types are *Prunus Virginiana*, *Ribes gracile*, *Ulmus fulva*, *U. Americana*, *Quercus macrocarpa* and occasionally *Morus rubra*. (From Vol. V, Iowa Geol. Surv.)

Figure 15. One of the smaller valleys, the Floyd, in Plymouth county. The stream is bordered with *Salix amygdaloides*, *Ulmus Americana*, and herbaceous plants like *Anemone Pennsylvanica*, *Phlox pilosa*, *Elynus robustus*. These soils are often very moist in the spring. (From Vol. VIII, Iowa Geol. Surv.)

Petalostemon candidus,	*Petalostemon violaceus*,
Potentilla arguta,	*Cassia chamæcrista*,
Lactuca pulchella,	*Coreopsis palmata*,
Verbena stricta,	*Convolvulus sepium*,
Euphorbia corollata.	*Verbena bracteosa*.

August and September list—

Solidago Missouriensis,	*Solidago rigida*,
Aster sericeus,	*Aster multiflorus*,
Ambrosia psilostachya,	*Helianthus Maximiliani*,
Cnicus discolor,	*Euphorbia marginata*,
Euphorbia maculata.	*Euphorbia dictyosperma*.

Loess grasses—

Bouteloua racemosa,	*Andropogon scoparius*,
Panicum virgatum,	*Andropogon provincialis*,
Andropogon nutans.	*Panicum virgatum*,
	Sporobolus cuspidatus.

Sporobulus cuspidatus forms thick interlacing rootstocks that firmly bind the soil. Where it grows it forms a most conspicuous feature of the vegetation. It usually grows in newer made soil being much younger than the formation occupied by *Andropogon provincialis* and *A. scoparius*.

Few shrubs occur upon the open grassy meadows. A few however should be listed here.

Ceanothus ovatus,	*Rhus glabra*,
Rosa blanda var. *Arkansana*.	*Amorpha canescens*.
Symphoricarpos occidentalis.	

It should be stated here that the other shrubs like *Corylus Americana* and *Prunus Virginiana* are found in close proximity to the woods. The *Rhus glabra* also spreads from the borders of woods reaching out into the meadows and is a forerunner of a forest growth.

AMES.

Early flowering plants of Ames during April and May are as follows:

Anemone patens var. *Nuttalliana* (rare),	*Sisymbrium canescens*,
Viola pedata,	*Viola palmata* var. *cucullata*,
Oxalis violacea,	*Oxalis corniculata*,
Astragalus carycocarpus,	*Taraxacum officinale*,

Lithospermum canescens, *Lithospermum angustifolium*.
Castilleia sessiliflora.

Of the later blooming plants—

Anemone cylindrica, *Delphinium azureum*,
Lepidium apetalum, *Phlox pilosa*,
Verbena bracteosa, *Hedeoma hispida*,
Rumex acetosella, *Poa pratensis*,
Poa compressa, *Echinacea angustifolia*,
Achillea millefolium, *Troximon cuspidatum* (rare).
Lobelia spicata, *Erigeron strigosus*.
Antennaria plantaginifolia.

Of the June and July plants—

Asclepias verticillata, *Psoralea argophylla*,
Petalostemon violaceus, *Petalostemon candidus*,
Erigeron divaricatus, *Cassia Chamæcrista*,
Potentilla arguta, *Liatris cylindrica*,
Solidago Missouriensis, *Coreopsis palmata*,
Verbena stricta, *Euphorbia corollata*.
Panicum pubescens.

Of the shrubs we may mention—

Ceanothus ovatus, *Rhus glabra*,
Rosa blanda var. *Arkansana*. *Amorpha canescens*.

The shrubs in the drift hills are not much more conspicuous than near Woodbine and Missouri Valley.

August and September list.

Solidago rigida, *Solidago nemoralis*,
Aster sericeus, *Aster multiflorus*,
Ambrosia psilostachya, *Heliopsis scabra*,
Cnicus discolor, *Artemisia caudata*,
Panicum capillare, *Euphorbia maculata*,
Andropogon scoparius, *Bouteloua hirsuta*,
Sporobolus asper. *B. racemosa*,
Panicum virgatum,
Aristida basiramea.

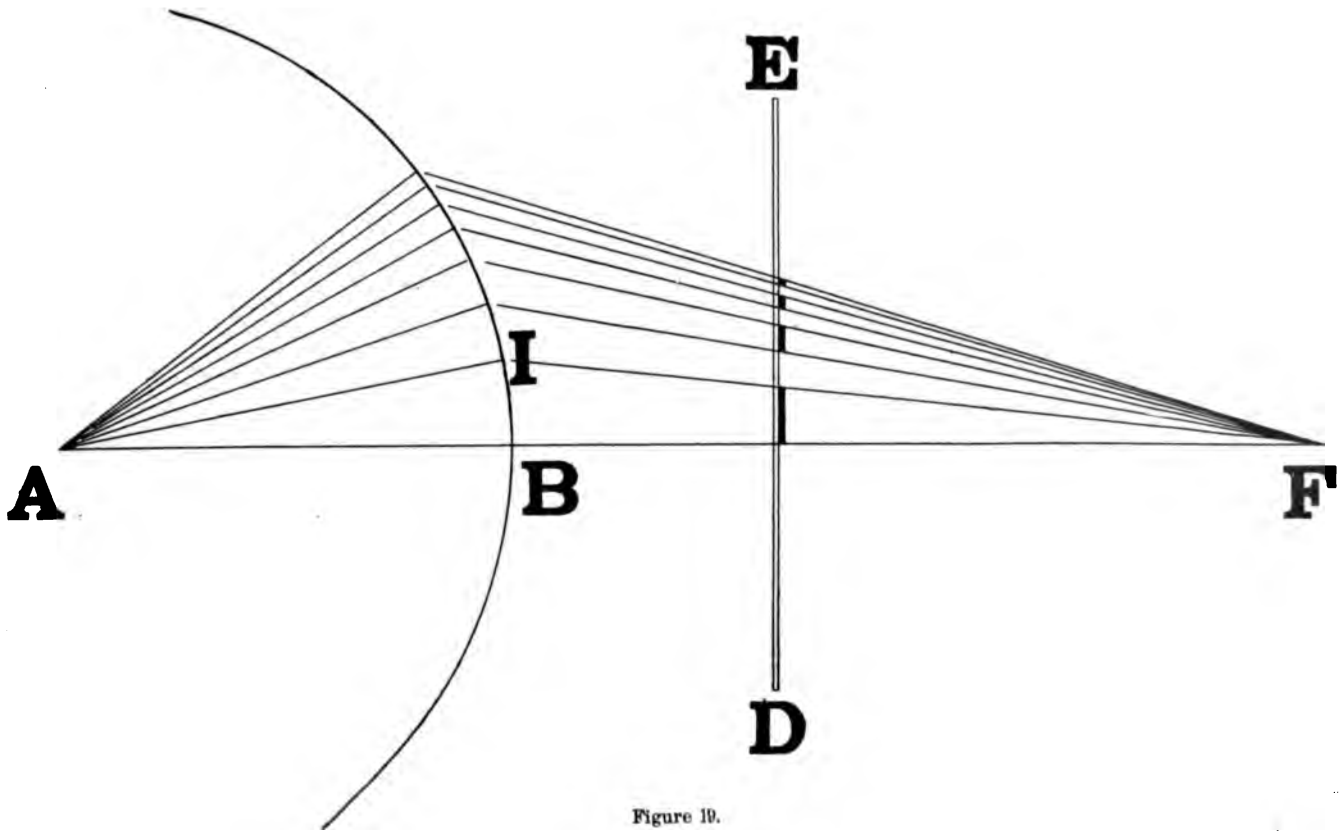


Figure 19.

A RULING ENGINE FOR MAKING ZONE PLATES.

BY W. M. BOEHM.

About a century ago the corpuscular theory of light was falling into disfavor among scientific men in general and the wave theory was taking its place. Among the many contributions to the subject we find the writings of Fresnel. It was he especially who struck the decisive blow at the dying hypothesis. That part of his work which is of particular interest to us is his application of Huyghen's principle to phenomena of diffraction.

According to this principle, every particle on the wave-front, I B, figure 19, may be regarded as the source and center of a new wave. Suppose our figure were a section through a wave. A is the center of the disturbance; I B part of the wave-front, and F some particle on the straight line passing through A B, and farther from A than the wave-front. We know that, in a homogeneous medium, I B, the section through the wave-front, will be an arc of a circle. If there is no opaque obstacle on the line between A and F, the wave will in time reach F, for light travels in straight lines in such a medium. But, suppose we had an obstacle between A and F. Why is it that we will not receive light from the other particles on the wave-front if, as we have said, each particle there acts as the center of a new wave? In other words, why will light not travel in a crooked or curved path in a homogeneous medium? Fresnel's explanation is not the most satisfactory but is sufficient for the present purpose.

He divides the wave-front into a number of zones. In the figure these are shown as arcs of a circle. The line I F is equal to B F plus one half a wave-length. The next

line is half a wave-length longer than I F, etc., every line is half a wave-length longer than the preceding. We will not go farther into these details since they are now too well known. Suffice it to say that, by simple mathematical means we can show that the motions given to F by any half zone are exactly balanced by the motions from the succeeding half zone as a result of destructive interference. There is one exception to this, *i. e.*, the motion transmitted by the particles in the immediate vicinity of B. The motion from these particles is what causes the motion of F. It is evident that when we interpose some obstacle, like the dark film of a photographic negative, so that the motions from each alternate zone cannot arrive at F, we will have the motions from the remaining alternate zones arriving a F, practically, at the same time and in the same phase. A negative of this kind will have a series of concentric circles whose radii are proportional to the square roots of the respective numbers of the circles. Soret, in 1875, produced a plate of ninety-eight dark circles and obtained some very satisfactory results. In 1898 Prof. Wood, then of the University of Wisconsin now of Johns Hopkins, made a plate of 115 dark circles. He also produced phase-reversal plates, *i. e.*, plates which were entirely transparent but in which the alternate zones would retard the motion by one half a wave length. His results, in addition to a plate, were published in the *Philosophical Magazine* for that year. His plates were made by first producing a drawing and photographing it afterwards. He used an ordinary beam-compass. Now, anyone who has had the fortune to manipulate one of these instruments can appreciate the value of a steady hand, when he obtains good results. It was with the intention of producing these plates with greater ease and accuracy that an engine, or rather machine, was built at the University of Iowa this year.

Mechanical details are always tiresome but, if you will draw on your liberal supply of patience, we will consider the engine which has enabled us to make plates of, not 230

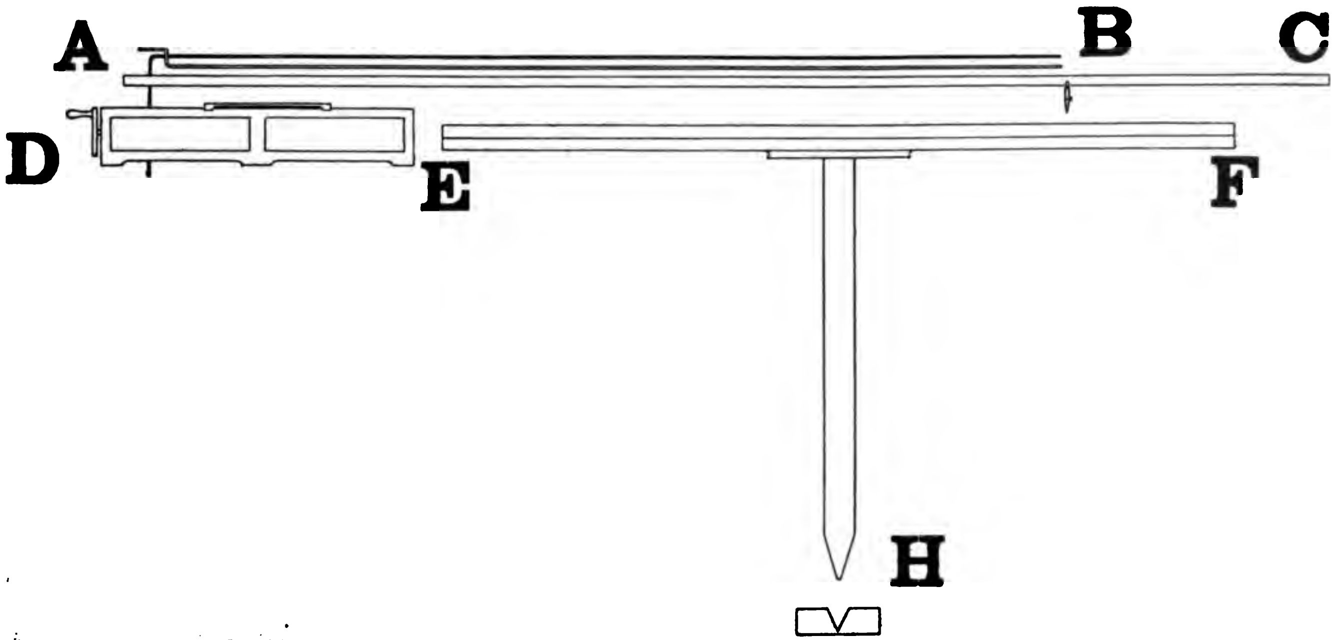


Figure 20.

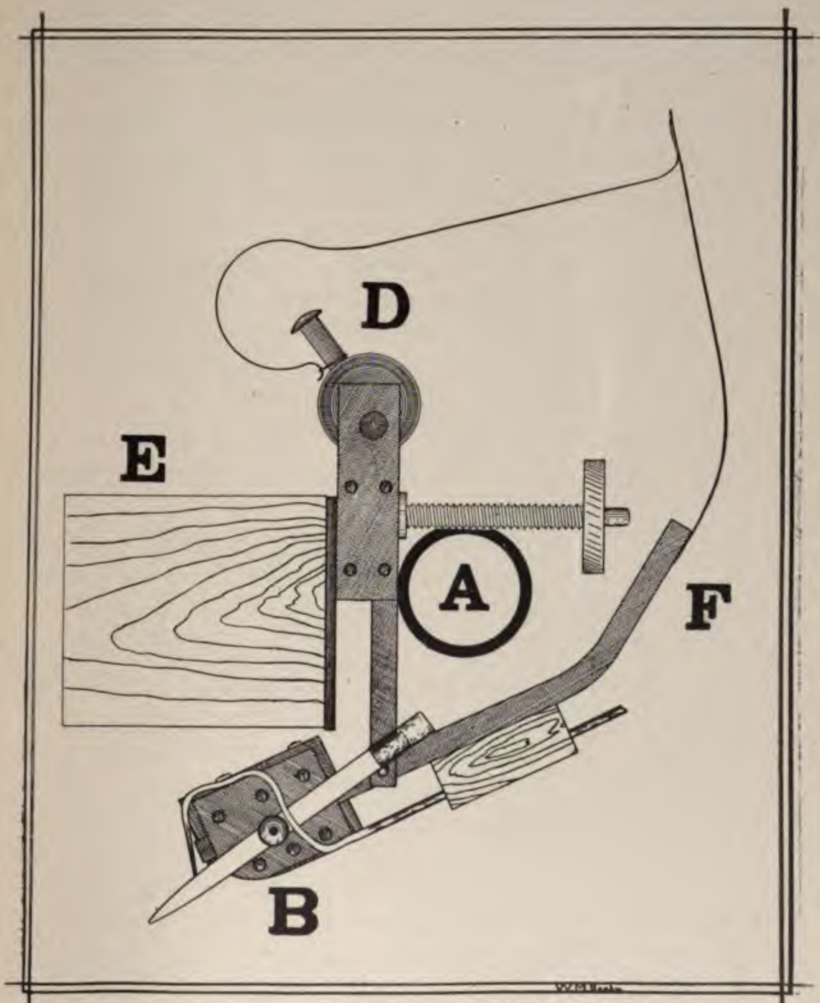


Figure 21.

circles, but of 900 circles, in the short time of eighteen hours.

First of all, the pen was not made to move about a center and describe a circle as in the ordinary process, but the drawing-board was made to revolve and the pen held stationary. In its general outline the machine may be seen in figure 20. A C is a long gas-pipe, selected on account of its smooth surface and cylindrical form. At B the drawing pen is attached. The operator governs it by means of a long brass rod between A and B. This enables him to lift the pen from the paper and lower it at will. Parallel to this rod there runs a long capillary tube through which ink is forced into the pen. The gas-pipe is fastened to the bed of the dividing-engine D E. The drawing-board is supported by a heavy steel shaft which rests in a conical bearing at H.

Figure 21 shows the method of attaching the pen to the gas-pipe, A. Two brass bars, D B and B F, form a hinge. The pen is fastened at B by an arrangement which permits its removal. Here may also be seen the glass capillary tube through which the ink is forced into the pen. This tube is fastened to the hinge in such a manner that the pen can be filled at any position of the hinge. A rubber tube, not shown in the drawing, connects this glass tube with the capillary tube running to the operator's table. At F there is a spring which tends to keep the pen pressed mildly against the surface of the paper. When the operator desires to lower the pen he turns the eccentric at D so as to draw F against the pipe and the pen at B descends. In order to lift the pen he reverses the process and the spring, which is attached to a screw at D, is drawn in the opposite direction. Thus one spring is made to do the work of two. At one time there was a second spring employed to raise the pen but it was found obnoxious and was soon discarded. The screw which you see above the pipe at A is not used when a drawing is made. Its purpose is to hold the point of the pen in a constant position so that depressions in the drawing table may be detected.

While the work is proceeding the pen becomes empty. The operator must have some means of watching the pen and the paper just below it. For this purpose a mirror, E, is attached at an angle of about forty-five degrees to the plane of the drawing-board. This reflects the image of the pen toward the operator's telescope. Occasionally, the pen must be cleaned. This can be done without disturbing its position. The width of the line can also be regulated. The hinge is made to fit closely in order to prevent a motion of the pen from side to side. To provide an additional safeguard against this possibility, a strong wire spring, not shown in the drawing, is attached to F so as to keep the end of the hinge drawn always to one side. The pen can be moved up or down by gentle pressure but not from side to side. It follows any slight elevation or depression in the surface of the drawing-board.

One of the most perplexing of the problems that had to be solved was that concerning the drawing-board. Suppose we had a board seven feet square. In a damp atmosphere it would swell more in one direction than in the other, which is a very undesirable property in this case. Suppose you made your board in two sections, an upper and a lower, having the long fiber at right angles. You would be adopting the method of the man who made the wooden saddle. The surface of the board would not be a plane. After some deliberation the following method was adopted: several pieces of broad pine flooring were taken and a line drawn down the middle of the broad side. Fifteen of these pieces were laid side by side so as to leave about three millimeters between each board and the adjoining one. Over these was placed a second layer of boards with their medial lines also marked. Wherever two of these medial lines intersected a screw was driven. In all about 230 screws. This gives a board which will hold its shape sufficiently for the present purpose. The expansion in the direction of the long fiber is very small. At right angles to this direction let the wood shrink or swell for we have given it sufficient room to do so in the

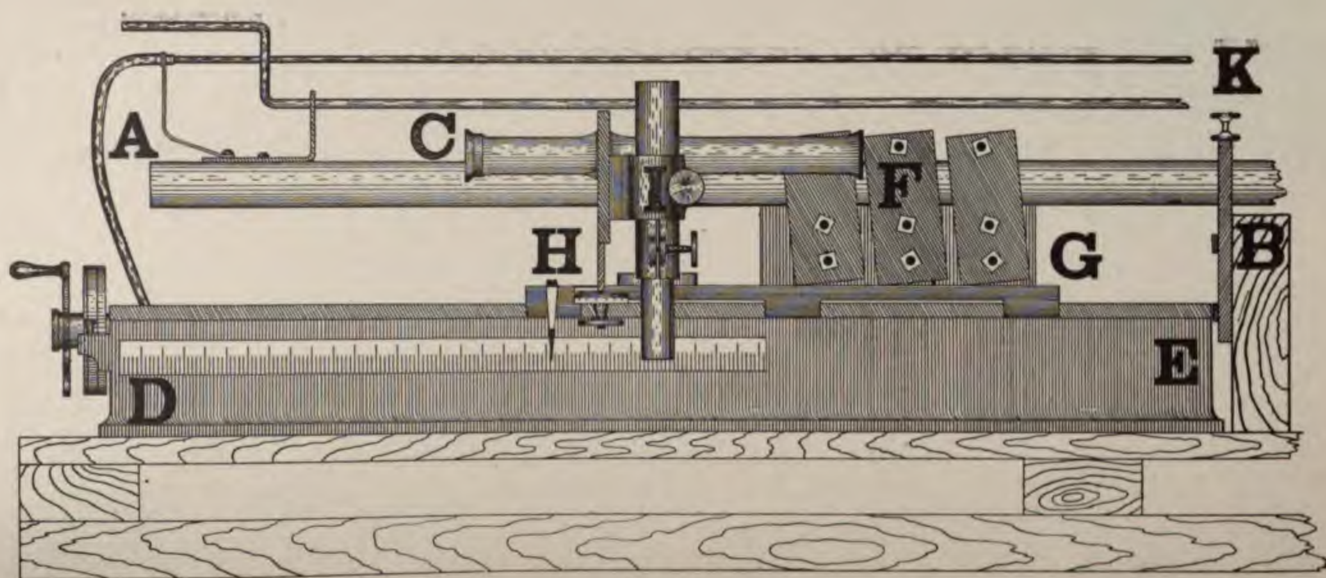


Figure 12.

interspaces. The board is revolved at the rate of about one revolution in twenty seconds, by means of a small electric motor and a system of pulleys. Both motor and the pulleys have separate structures. The motor is placed on a pier which is free from mechanical contact with the building. The vibrations produced otherwise do not reach the pen or board so that the machine is practically free from all ordinary vibrations.

The diameter of this drawing-board is about 2.10 meters. The sheet of paper used was seventy-two inches wide. [Since drawing-paper is a commercial article, the ancient system is, of course, used.] The dividing-engine D E, figure 22, is only 45 cm. long. Now we should have a screw of more than 100 cm. in length. In order to get around this obstacle the following method was adopted: the gas-pipe, A B, was passed through two supports, K B, one at each end of the drawing-table. They were provided with screws, K, so that the pipe could be firmly fastened and not moved backward or forward. To H G, the movable bed of the engine, a solid iron bar, G, having the same width as the gas-pipe, is fastened. To this, in turn, are fastened three flat brass bars seen at F. A visitor once remarked that they reminded him of the inclined stacks of an ocean steamer, but you may rest assured that the artistic effect was not thought of during the construction of the apparatus. When mechanical perfection is impossible it is well to provide for the imperfections that are detrimental. No attempt was made to drill a hole through which the bolts would exactly fit. When the operator desires to fasten the pipe to the engine he first forces the bars back as far as possible and fastens the two lower bolts. Then the upper bolt is fastened and thus the pipe is firmly clamped to the bed of the engine. In order that the operator may make measurements and watch the actions of the pen there is mounted, at I, a Frauenhofer telescope, C F. It is shown a little higher than the gas-pipe but when in operation it is much nearer the same elevation. From A to K are shown in part, the lever which raises the pen and parallel to it the capillary tube for conveying the

ink. An injector or, what is more to the point, a force-pump forces ink through the tube and into the pen. It is operated by hand. Along the side of the dividing-engine you may see a scale. A pointer from H shows the number of complete turns of the screw.

Figure 23 shows the engine as seen from the operator's end; the mounting of the telescope between F and I; the attachment of the gas-pipe between A and F; and at D the pointer to the side of the engine. There are two other pointers to be seen here. They are flexible pointers for the divided head which is of a peculiar construction.

Instead of having one divided circle it has three. This was invented after half of the first zone plate was completed and its value is quite apparent from the striking difference in the results obtained. In order to set the engine the figures were taken from a table of square roots, but these could not be used directly since the factor used in this case was thirty. It was simple enough to multiply by ten but to multiply by three involved the manipulation of some thirty thousand figures. It was an immense task but was cheerfully begun. The use of the new scale at the side of the engine, combined with the new form of the divided head, now makes it possible to set the engine directly from the tables without the use of another figure. It may be well to state here that the method of this divided head may be applied in a general manner. The head may be divided into any number of circles, not necessarily three, but the complementary scale, H, figure 24, should be divided into the same number of parts for direct reading. If you will look at this scale, H, you will see that each divisions represents a complete turn of the screw and every third division is numbered in succession. Suppose, for instance, you were to set the engine at 11. 85. You would turn until the pointer on the scale, H, stood at 11. 00. Now you would look at the divided head and use the outer circle, but you would not find .85 on this. It reads from ⅓. Turn the screw one complete revolution and nter on H would be on the next division which is 1. Look at the divided head once more and use

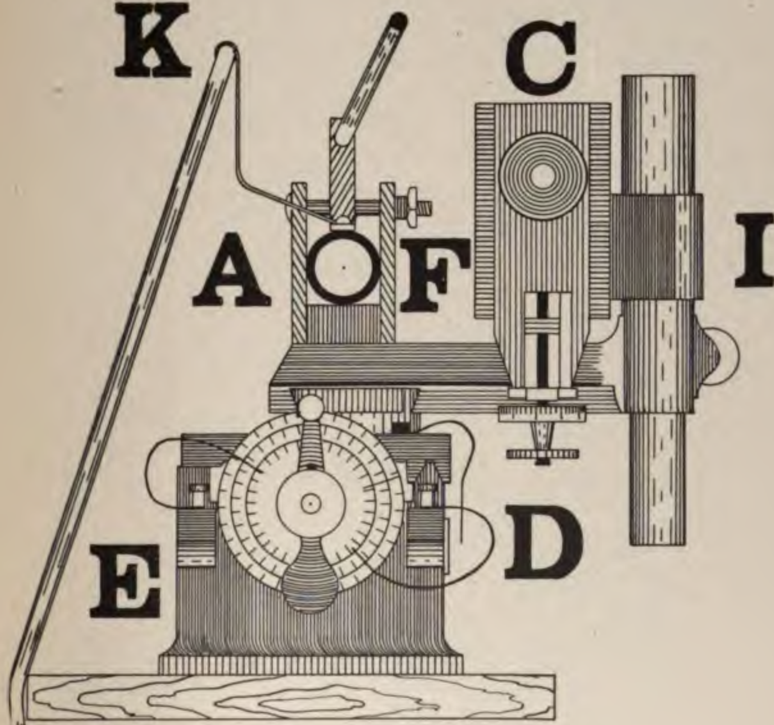


Figure 23.

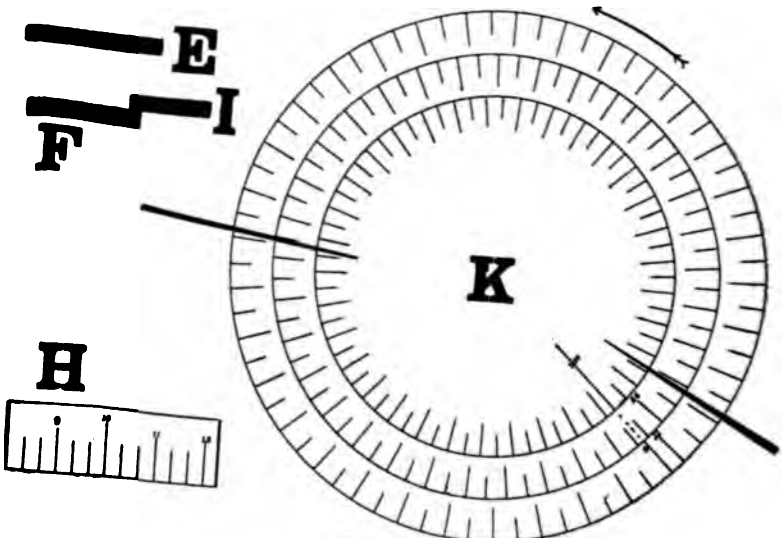


Figure 24.

the middle circle. It reads from .33⅓ to .66⅔, not so far as .85. Turn the screw another complete revolution and look at the divided head; use the inner circle this time It reads from .66⅔ to 1.00. The pointer on H is at the second unmarked scale, but if you turn till the divided head is set at 1.00 you will find the pointer on H at 12.00. Every third division on H is marked in succession. There are three spaces between 11.00 and 12.00. They correspond to three turns of the screw. The two unmarked divisions show which circle, on the divided head, to use.

The two pointers are used to allow for the width of the pen. The one at the right was used for the odd-numbered circles. Suppose the position of one of these circles were the lower margin of E, figure 24. If we had only this one pointer your next line would be at I, say. But, this is too far in a light zone by just the width of the line drawn by the pen. The pointer at the left is set so that, turning the head from the one on the right in the direction indicated, will move the pen forward just the width of the line it draws. The operator then works by the following method: he draws the line E by setting the head on the right pointer. For the next line he again turns until the proper figure appears at this pointer but instead of drawing I he turn and sets by the left pointer. He then draws F. The process is quite simple and the operator becomes mechanical in his actions as the work proceeds.

There is one more point to consider before closing: When the work is done with the beam compass, a small conical hole in a tack serves as the center for all the circles. We cannot do that with the present machine. In order to have the pen pass through the axis of the drawing-table, or through the center of the circle it draws, the table is firmly clamped and the pen moved over the paper. It traces a long straight line. Now the board is revolved through 180 degrees, firmly clamped, and the pen moved over the surface as before. If the two lines coincide, the pen passes through the center; if not, it can be adjusted until it does.

There are other details of more or less importance but they must be omitted. In its present condition the engine leaves room for improvement and improvements are continually being made. If it were to be reconstructed now, it would probably be slightly different from its present form. Many suggestions have been made; some are good, others worthless. In the face of these it is well to remember the words of Mueller:

"Wer jeden Rath berathen will der kommt zu keiner that."

Just what the final results of the investigations with the plates will be only a prophet can tell. This will form the subject-matter for other papers. It has not been the object to consider the plates themselves, but the engine with which we make them. We have been enabled to construct plates of 930 circles, more than four times the number drawn by Prof. Wood, but we can admire the patience with which he applied a beam compass to 230. The investigations with the plates will probably take two years of time at least and then the results may be negative. But what is the spirit of the scientist if not to throw aside years of labor and the most favored opinions, that the truth may be seen more clearly.

The engine was first planned after January 1, 1901. In its present imperfect condition it stands as the interrupted work of the past year. Had it not been for Professor A. A. Veblen, president of this learned body, the work would have come to an abrupt close before this. For his encouragement and many valuable suggestions I desire to express my gratitude.

A LIST OF PLANTS COLLECTED IN LEE COUNTY, FLORIDA.

BY A. S. HITCHCOCK.

The plants included in the following list were collected at several points in Lee county, Florida, in July and August, 1900. My headquarters were at Myers, on the Caloosahatchee river, at which place most of the numbers were collected. Collections were made also at Alva, about twenty-five miles up the river, at Punta Rassa and Sanibel, at the mouth of the river, and at Marco, an island a considerable distance down the coast. A few plants were collected at Everglade, at the southwest corner of the county. Of all the plants in proper condition and in sufficient abundance, ten sets were prepared. Full sets contain 500 forms, though the total numbers are 549. Several species were obtained which are not represented in the sets.

In the vicinity of Myers the most extensive formation is the flatwoods. This is flat, sandy land covered with forest of the long-leaved pine. Beneath is the saw palmetto with other low shrubs, such as scrub oak and *Andromeda fruticosa*. In the flatwoods are ponds which contain water the year around. Various water plants grow here and there is usually a growth of button bush (*Cephalanthus*) in the central part. Other depressions contain cypress trees and are called cypress swamps. Besides these there are shallow depressions which contain water only during the rainy seasons and which I have called wet-weather ponds. Such depressions are characterized by the absence of the pines and saw palmetto and the presence of certain herbs, which, in most cases, are also found around the ponds. Around the permanent ponds there is usually a broad open space

between the saw palmettos and the water, covered with a carpet of low herbs. Hammocks are small areas of richer soil and hence covered with a more dense forest vegetation. If cabbage palmettos predominate it is called a palmetto hammock. Bay-heads are rich, swampy areas covered with dense forests in which the bay tree is found. Along the river are marshy flats, in many cases devoid of forests, except what are called palmetto flats, where the cabbage palmettos are scattered over the surface.

Along the seacoast there is the usual strand flora, back of which is generally a line of low dunes upon which grow thickets of tropical plants such as *Pithecolobium Unguis-Cati* and *Forestiera porulosa.* In places the strand will extend back into a sandy, flat prairie covered with bunch grasses and herbs. Where the soil is low enough to be under water at high tide, mangrove swamps flourish. The chief species here are *Rhizophora, Avicennia* and *Laguncularia.* Below is likely to be a carpet of *Batis maritima, Sesuvium* and *Salicornia.* In other places there are extensive salt marshes covered by grasses and sedges, such as *Spartina juncea* and *Fimbrystilis castenea.* These are the chief formations observed.

MAGNOLIA GLAUCA, L. Myers. Rather common in bay-heads.

ASIMINA GRANDIFLORA, Dunal. Myers, Marco. Flatwoods. Frequent, but only three specimens found in flower. A small shrub about two feet high.

ANONA LAURIFOLIA, Dunal. Myers (1). Along the banks of the Caloosahatchee river. A small tree about eight to ten feet high. In fruit. Fruits ovate, somewhat unsymmetrical, about four inches long; green, more or less distinctly facetted.

ARGEMONE LEIOCARPA, Greene. Myers. A weed along streets. Only a few specimens observed.

LEPIDIUM VIRGINICUM, L. Marco, Myers (2). A weed along streets. Frequent but apparently common earlier in the season.

CAKILE MARITIMA, Scop. Sanibel, Punta Rassa. Sandy seashore. Infrequent. A bushy branched herb, the divergent branches decumbent.

POLANISIA TENUIFOLIA, T. and G. Marco.

CAPPARIS CYNOPHALLOPHORA, L. Marco, Everglade. Near a mangrove swamp. Infrequent.

HELIANTHEMUM CORYMBOSUM, Michx. Marco, Myers (3). Flatwoods, especially in open places.

LECHEA TENUIFOLIA, Michx. Marco, Myers (4). Flatwoods. Common.

LECHEA MAJOR, Michx. var. *Divaricata*. Myers. Flatwoods.

STIPULICIDA FILIFORMIS, Nash. Myers (5). In a cultivated field. Uncommon.

MOLLOGO VERTICELLATA, L. Myers (10). A weed in cultivated soil.

TRIANTHEMA PORTULACASTRUM, L. Marco (9). Flat shell land near water on seacoast. Most abundant in muddy depressions where it forms a carpet.

SESUVIUM PORTULACASTRUM, L. Myers and Sanibel (11). Salt marshes especially among the mangroves.

PORTULACA OLERACEA, L. Punta Rassa, Myers (8). Cultivated fields. Apparently indigenous on the shell mounds at Marco and also in other localities. Plant usually lacks the red or purple color common in the north.

PORTULACA HALIMOIDES, L. Marco (5). On shell mounds among cactuses in an exposed situation. Observed in but one locality, where it was in considerable quantity.

PORTULACA PILOSA, L. Myers (7). Flatwoods and also cultivated fields. Common.

ASCYRUM HYPERICOIDES, L. Myers (17). Flatwood ponds, along the border among the palmettos. A shrub two to four feet high.

ASCYRUM STANS, Michx. Myers (16). Along the border of flatwood ponds. Frequent.

ASCYRUM AMPLEXICAULE, Michx. Myers (15). Flatwoods, common. A low shrub.

HYPERICUM MYRTIFOLIUM, Lam. Myers (14). Flatwood wet weather ponds. Shrub one to three feet high. Frequent.

HYPERICUM ASPALATHOIDES, Willd. Myers (13). Borders of flatwood ponds. Common.

HYPERICUM OPACUM, T. and G. Myers (12). Marco. Flatwoods. Common.

MALVASTRUM RUGELLII, Wats. Everglade, Myers (22). A weed along the streets. Frequent.

SIDA CORDIFOLIA, L. Marco, Myers. Waste places. Not common.

SIDA RHOMBIFOLIA, L. Marco (23), Punta Rassa. A weed along edge of field (No. 23) and in waste places. Common at Marco.

SIDA ACUTA, Burm. Marco, Myers (24). A common street weed; shrubby at base; a foot or two high. Flowers yellow or orange, opening in sunshine in forenoon.

SIDA RUBRA-MARGINATA, Nash. Punta Rassa (25), Myers. At Punta Rassa it was abundant in the sandy flats or prairies near the coast. An erect shrub one to three feet high or in protected places as much as five feet high. Stem and margin of leaves purple.

URENA LOBATA, L. Myers (550). A weed along the streets and in waste places.

KOSTELETZKYA SMILACIFOLIA, Gray. Myers (18) (19), Marco. Along Caloosahatchee river (No. 18) and fresh water swamps (No. 19). No. 18 agrees with description and Simpson's specimen. No. 19 has narrow leaves, slender, wide spreading stems and flowers only about half as large.

KOSTELETZKYA ALTHEAEFOLIA, Gray. Sanibel (20), Marco (21). Salt or brackish marshes near coast. No. 20 leaves small and plant widely spreading. No. 21 leaves usual shape, but neither this nor 20 have the dense velvety pubescence of other specimens, *e. g.* Curtiss, 5696.

GOSSYPIUM HERBACEUM, L. Sanibel, Myers, Marco. More or less shrubby. Occasional plants have become established.

MELOCHIA HIRSUTA, Cav. var. *Glabrescens*, Gray, Myers, (26). In grass along streets. Not observed in the flatwoods outside of town. Flowers light purple, opening in the morning. Plant diffusely spreading from the root.

WALTHERIA AMERICANA, L. Punta Rassa.

LINUM FLORIDANUM, Trel. Myers (33) (34). Flatwoods. No. 33 is the usual tall form growing among the palmettos. No. 34 is a low form found in shallow water in ponds.

OXALIS FILIPES, Small. Myers (35). A weed in waste places in town.

XANTHOXYLUM PTEROTA, HBK. Marco, Myers (36). In a brackish swamp thicket at Myers. Common along the coast in the dunes.

BURSERA GUMMIFERA, L. Myers, Marco (37), Sanibel, Everglade. No. 37 in swamp thicket. Frequent in scrub on dunes along coast.

RHUS TOXICODENDRON, L. Marco, Myers, Alva (39). Mostly in hammocks and bayheads.

RHUS COPALLINA, L. Marco, Myers (38). Forming thickets along streams.

ILEX CASSINE, L. Myers (48) (49). Bayheads. Fruit a bright scarlet. A tree twenty to thirty feet high. No. 48 is glabrous and No. 49 is puberulous.

ILEX GLABRA, Gray. Marco, Myers (47). Flatwoods near pond.

XIMENIA AMERICANA, L. Myers (40). Flatwoods and border of swamps. Fruit edible, oval; about the size of an olive. Yellow, with one stone much the shape of the olive stone. Called hog plum.

VITIS MUNSONIANA, Simpson. Myers (43), Alva (42), Marco. Climbing on bushes along streams.

VITIS CARIBÆA, DC. Myers (41). Climbing over small trees in open thickets near bayheads. Fruit ripening August 8th.

VITIS CANDICANS, Englm. var. *Coriacea*. Punta Rassa. A single vine near coast climbing over a small tree.

Fruit edible, nearly as large as domesticated sorts, light purple.

CISSUS STANS, Pers. Myers (45), Marco. On shrubs in open thickets along edge of permanent ponds.

CISSUS SCIDA, L. Marco.

CISSUS SICYOIDES, var. *Floridana*, L. Marco, Myers (46). Climbing high over shrubs and small trees along edges of bayheads.

AMPELOPSIS QUINQUEFOLIA, Michx. Myers (44), Everglade. Climbing over fences and over thickets along streams.

ACER RUBRUM, L. var. *Drummondii*, T and G. Myers. Bayheads.

CARDIOSPERMUM MICROCARPUM, HBK. Marco, Punta Rassa (50). Sandy flats near coast.

SAPINDUS SAPONARIA, L. Marco.

POLYGALA GRANDIFLORA, Walt. Myers (27), Punta Rassa, Sanibel. Common in flatwoods and sand dunes along coast. The type and varieties *canescens* and *angustifolia* intergrade. No. 27 has lanceolate to linear leaves smoothish or canescent. The specimens from the coast are usually canescent.

POLYGALA BOYKINI, Nutt. Myers.

POLYGALA INCARNATA, L. Myers, Sanibel. Flatwoods, occasional.

POLYGALA SETACEA, Michx. Myers (31). Flatwoods.

POLYGALA NANA, DC. Marco.

POLYGALA LUTEA, L. Myers (32). Along border of flatwood ponds.

POLYGALA RUGELII, Shuttl. Myers (28). Flatwoods.

POLYGALA RAMOSA, Ell. Myers (29). Flatwood ponds.

POLYGALA BALDWINII, Nutt. Myers (30). Flatwood ponds.

CROTALARIA SAGITTALIS, L. Myers (64) (65). Moist grassy places near streams.

CROTALARIA OVALIS, Pursh. Myers (63). Flatwoods.

CROTALARIA PURSHII, DC. Marco, Punta Rassa (62). Sandy seacoast.

COTALARIA INCANA, L. Myers, Punta Rassa (61). Waste places; two to four feet high.

LUPINUS DIFFUSUS, Nutt. Punta Rassa, Marco. Sandy fields near ocean.

PETALOSTEMON CARNEUS, Michx. Myers (75). Flatwoods near ponds.

AMORPHA VIRGATA, Small. Myers (52). Along streams.

TEPHROSIA SPICATA, T. and G. Myers (82). Flatwoods; flowers white, fading to pink.

TEPHROSIA CHRYSOPHYLLA, Pursh. Myers (81). Flatwoods. Also a weed in fields; several prostrate stems, two to four feet long from a strong root.

TEPHROSIA LEPTOSTACHYA, DC. Myers (83). A weed in orange grove.

INDIGOFERA CAROLINIANA, Walt. Myers (73), Alva. A weed in old fields. Occasionally in flatwoods.

INDIGOFERA TINCTORIA, L. Myers. A weed in waste places.

SESBANIA MACROCARPA, Muhl. Marco. A weed in waste places.

VICIA ACUTIFOLIA, Ell. Myers. Marco (84). Salt marshes, climbing on tall grasses and rushes.

AESCHYNOMENE VISCIDULA, Michx. Myers (51). Flatwoods. Rare.

DESMODIUM TORTUOSUM, DC. Myers (66). In an old field.

DESMODIUM PANICULATUM, DC., var. *Chapmani*, Britt, Myers.

DESMODIUM RHOMBIFOLIUM, DC. Myers (67). Along ditches.

DESMODIUM TRIFLORUM, DC. Myers. Open ground, common.

RHYNCHOSIA MENISPERMOIDES, DC., Sanibel. Myers, (79). Flatwoods. Also is a weed in fields.

RHYNCHOSIA CINEREA, Nash. Punta Rassa, Myers.

APIOS TUBEROSA, Moench. Myers, Alva (86). Hammock along river.

VIGNA LUTEOLA, Benth. Myers (85). These are var. *augustifolia*. Mucky bank of Caloosahatchee. Also in brackish waters.

ERYTHRINA HERBACEA, L. Marco, Myers. Flatwoods, at Marco is frequent on the shell mounds.

CENTROSEMA VIRGINIANA, Benth. Myers and Punta Rassa (60). Flatwoods, var. *augustifolia*, Sanibel, leaflets one

and one-half inch long, one-fifth inch wide. Marco, leaflets as much as two and one-half inches long, one-fifth inch wide.

GALACTIA CUBENSIS, HBK. Everglade, Marco.

GALACTIA PILOSA, Ell. Moers (69), Punta Rassa (70), Marco. Climbing on shrubs near flatwood pond (No. 69) and along sea coast (No. 70). No. 69 has narrow leaflets while No. 70 has oval leaflets.

GALACTIA GLABELLA, Michx. Marco (71), Myers (72). Climbing on scrub oak in a small "scrub" (No. 71). A weed in an orange grove (No. 72). Frequent in flatwoods and in cultivated soil.

GALACTIA ELLIOTTII, Nutt. Marco, Alva, Myers (68). Flatwoods. A single specimen from Myers is ferruginous-tomentose.

CANAVALIA OBTUSIFOLIA, DC. Punta Rassa (54), Marco, Sanibel, Myers (90). Climbing over shrubs along coast.

PISCIDIA ERYTHRINA, L. Sanibel, Marco, Punta Rassa (76). Scrub along sea coast, small tree eight to ten feet high.

ECASTOPHYLLUM BROWNEI, Pers. Myers, Punta Rassa, Marco. Along sea coast, usually forming small thickets two to three feet high between the scrub and the water.

SOPHORA TOMENTOSA, L. Punta Rassa (80), Sanibel, Marco. Scrub along coast. A scrub four to ten feet high.

CASSIA OCCIDENTALIS, L. Myers (59). A weed in waste places.

CASSIA TORA, L. Marco, Myers (58). A weed in waste places.

CASSIA CHAMÆCRISTA, L. Marco, Myers (55). Flatwoods, especially near ponds; two to four feet high.

CASSIA ASPERA, Michx. Sanibel, Marco, Alva (56), Punta Rassa (57). Sandy fields. Especially abundant in old fields.

CÆSALPINIA BONDUC, B. and H. Myers, Punta Rassa, Marco (53). Scrub on sand dunes.

PITHECOLOBIUM UNGUIS-CATI, Benth. Marco, Everglade, Myers (77). Scrub along coast. Common. A small form was found at Marco, Punta Rassa (78). A bush

four feet high, leaflets one-half to three-fourths inch long, somewhat coriaceous and a bright green. Heads of flowers small on short peduncles. Seems different from *P. unguis-cati.*

ACACIA FARNESIANA, Willd. Sanibel, Marco. Waste places; apparently introduced.

NEPTUNIA FLORIDANA, Small. Punta Rassa (74). In grassy depressions along the seacoast. Observed in but one place.

CHRYSOBALANUS OBLONGIFOLIUS, Michx. Myers, Marco. Flatwoods. A low shrub, about two feet high.

CHRYSOBALANUS ICACO, L. Punta Rassa (87). Forming small thickets two to three feet high on the strand, between scrub and water. Fruit about an inch or an inch and a half long, white with pink blush, edible. Called coco-plum.

RUBUS TRIVIALIS, Michx. Myers. Flatwoods near streams.

ITEA VIRGINICA, L. Myers.

RHIZOPHORA MANGLE, L. Marco, Myers (94). Muddy shores of salt or brackish water. Common.

LAGUNCULARIA RACEMOSA, Gaertn. Myers (95). Habitat similar to that of mangrove and often mixed with it.

CONOCARPUS ERECTUS, Jacq. Sanibel, Myers (96). Mangrove swamps and salt marshes. var. *Serica*, Myers.

EUGENIA AXILLARIS, Willd. Punta Rassa, Myers (99), Marco (98). In scrub near the coast, a small tree. At Myers on the border of a brackish swamp. At Marco on shell mounds.

EUGENIA BUXIFOLIA, Willd. Marco (100). Shell mounds. A shrub about six feet high.

PSIDIUM GUAVA, Raddi. Myers (97). Escaped and well established along roads and in waste places.

RHEXIA LANCEOLATA, Walt. Myers (88). Depressions in flatwoods or borders flatwood ponds. Common.

RHEXIA FLORIDANA, Nash. Myers.

RHEXIA CILIOSA, Michx. Myers (89). Borders of flatwood ponds among the palmettos.

RHEXIA SERRULATA, Nutt. Myers, Marco, Alva. Wet places in flatwoods.

AMMANNIA LATIFOLIA, L. Myers (101). Salt or brackisl marshes among the grasses and rushes More or les succulent.

AMMAMNIA HUMILIS, Michx. Myers (102). Moist, sandy soi near river.

LYTHRUM ALATUM, Pursh. Myers (103). Border of flatwoo ponds in clumps of grasses near bayhead.

LYTHRUM LINEARE, L. Myers (104). Salt marshes amon tbe grasses. Fowers white.

PROSERPINACA PALUSTRIS, L. Myers (93). Borders of flat wood ponds.

PROSERPINACA PECTINACEA, Lam. Myers (92). Borders c flatwood ponds, often in shallow water.

MYRIOPHYLLUM HETEROPHYLLUM, Michx. Myers (91). Pe manent ponds in flatwoods in about three feet of wate

GAURA ANGUSTIFOLIA, Michx. Myers (123), Sanibel. Flat woods and sandy prairies.

JUSSIAEA PERUVIANA, L. Myers (122). Habitat and siz similar to (121).

JUSSIAEA PILOSA, HBK. Myers (121). Along ditches an near freshwater marshes. Plant erect, four to six fee high.

LUDWIGIA VIRGATA, Michx. Myers (120), Marco. Flat woods.

LUDWIGIA LINIFOLIA, Poir. Myers (119). Wet weathe ponds in flatwoods, growing in the water. Plant erec with runners or offsets beneath the surface of th water.

LUDWIGIA CAPITATA, Michx. Myers (118). Flatwood pond mostly in the water.

LUDWIGIA ALATA, Ell. Myers (113). Along streams in ric soil and along edge of sphagnum bog.

LUDWIGIA MICROCARPA, Michx. Myers (117). Border o flatwood ponds.

LUDWIGIA PALUSTRIS, Myers (114), (551). Near streams i high grass, forming a dense mat, the prostrate stem rooting at the nodes, No. 114, in new soil near river.

LUDWIGIA CURTISSII, Chapm. Marco, Sanibel, Myers (115), (116). Wet weather pond or flatwoods growing in the water. Plants erect.

MENTZELIA FLORIDANA, Nutt. Marco. Shell mounds.

PIRIQUETA CAROLINIANA, Urb. var. *Glabra*, Urb. Sanibel, Myers. Gravelly prairies.

PASSIFLORA SUBEROSA, L. Marco.

PASSIFLORA ANGUSTIFOLIA, Sw. Marco (105). Shell mounds. Lower leaves three-lobed.

PASSIFLORA PALLIDA, L. Myers.

CARICA PAPAYA, L. Marco (106). Shell mounds along edge of mangrove swamp among shrubs and small trees. Seemingly indigenous; four to six feet high. Fruit about one to two inches long; yellow.

MELOTHRIA CRASSIFOLIA, Small. Myers (107), Marco (108), Sanibel, Punta Rassa. Climbing on weeds in a fresh water marsh at Myers. No. 108 on shell mounds.

MOMORDICA CHARANTIA, L. Myers. An escape along the streets.

CITRULLIS VULGARIS, Schrad. Myers. In waste places.

OPUNTIA sp. Sanibel, Marco (110). With the aspect of *O. Missouriensis.* Abundant on shell mounds at Marco Joints vertical but mostly prostrate, oval or nearly circular; about four inches long. Very spiny. Fruit purple; an inch or less long, scarcely longer than wide.

OPUNTIA TUNA, Mill. Myers (111). Along coast. Joints large, as much as a foot long, only slightly spiny Fruits tapering at base two to three inches long; several on the same joint. Plant often four to six feet high.

CEREUS COMPRESSUS, Mill. Marco (109), Sanibel. Abundant on shell mounds at Marco, clambering over shrubs or trailing on the ground. Flowers nearly a foot long. Fruit globose, two inches in diameter, bright scarlet.

HYDROCOTYLE UMBELLATA, L. Myers (128) (129). Rich, mucky soil near the river. No 129 has tubers.

HYDROCOTYLE REPANDA, Pers. Myers (127). Rich, mucky soil near the river.

HYDROCOTYLE VERTICELLATA, Thumb. Myers (126). Rich, mucky soil near the river.

ERYNGIUM YUCCÆFOLIUM, Michx. var. *Synchætum*, Gray. Myers (124). Along borders of ponds and bayheads.

ERYNGIUM BALDWINII, Spreng. Myers, Punta Rassa and Alva (125), Sanibel. Sandy river banks (Alva) and open ground an the coast.

CICUTA MACULATA, L. Myers. River banks and borders of marshes.

DISCOPLEURA CAPILLACEA, DC. Myers. Open ground.

TIEDEMANNIA TERETIFOLIA, DC. Myers. Ponds.

CORNUS STRICTA, Lam. Myers (112). Thickets near hammocks; six to ten feet high.

SAMBUCUS CANADENSIS, L. Myers (172). Bayheads and flatwood ponds.

VIBURNUM OBOVATUM, Walt. Myers (171), Marco. Bayheads and swamp thickets. A shrub four to six feet.

HOUSTONIA ROTUNDIFOLIA, Michx. Myers (183). Near flatwood ponds and also a weed in cultivated soil. Often forming large mats.

HOUSTONIA ANGUSTIFOLIA, Michx. Sanibel. Sandy prairies.

OLDENLANDIA GLOMERATA, Michx. Marco, Sanibel. Open sandy soil, in bunches.

OLDENLANDIA UNIFLORA, L. Myers (175). Among the grasses and sedges along the edges of wet-weather ponds. This seems distinct from *O. Glomerata*. Barnhart 2731 and Nash 1282 belong here.

RANDIA ACULEATA, L. Myers (182), Punta Rassa, Marco. Brackish swamps and dune thickets along the seashore.

CEPHALANTHUS OCCIDENTALIS, L. Myers (186). Flatwood ponds, usually in the central part, where the water remains throughout the year. Also along the river bank. A shrub as much as twelve to fifteen feet.

CHIOCOCA RACEMOSA, Jacq. Myers (185), Marco. Hammocks and rich thickets. Var. *Parvifolia*, Gray. Myers (184), Marco. Hammock near river (184.

PSYCHOTRIA UNDATA, Jacq. Myers. Brackish swamp thicket.

ɪYCHOTRIA TENUIFOLIA, Sw. Alva (181). In a palmetto hammock near the river. A shrub about a foot high.

ƦNODEA LITTORALIS, Sw. Punta Rassa. Along the seashore. Rare.

:CHARDIA SCABRA, L. Myers. Along streets.

'ERMACOCE TENUIOR, L. Myers (178). In ditches along the streets.

'ERMACOCE PARVIFLORA, Gray. Myers, Punta Rassa, Alva (179). Open sandy soil.

IODIA TERES, Walt. Myers (176), Punta Rassa. A weed in cultivated fields.

IODIA VIRGINIANA, L. Myers (177). Along the margin of flatwood ponds in the open ground. Abundant.

ALIUM PILOSUM, Ait., var. *Puncticulosum*, Gray. Myers.

ALIUM HISPIDULUM, Michx. Myers (180). Among shrubs around flatwood ponds.

LEPHANTOPUS TOMENTOSUS, L. Myers (141). Flatwoods.

IKANIA SCANDENS, Willd. Marco, Myers, Sanibel (158). Salt marshes. A form from Marco (=Curtiss, 1213* from No-Name Key), has small somewhat fleshy leaves. Plant smooth.

UPATORIUM FOENICULACEUM, Willd. Myers, Marco. A weed in waste places.

UPATORIUM MIKANIOIDES, Chapm. Myers, Marco, Sanibel (148). Salt marshes. Leaves vertical and rather succulent.

UPATORIUM SEROTINUM, Michx. Marco, Myers (147). Marshes and river banks.

UPATORIUM HYSSOPIFOLIUM, L. Marco, Myers (146). Flatwoods near ponds and depressions. Common.

UPATORIUM ROTUNDIFOLIUM, L. Myers (149). Around marshes and ponds.

UPATORIUM CŒLESTINUM, L, Myers, (150). In thickets around ponds.

IATRIS GRACILIS, Pursh. Myers (155). Around a flatwoods pond.

IATRIS TENUIFOLIA, Nutt. Marco (154). Flatwoods.

CARPHEPHORUS CORYMBOSUS, T. & G. Myers (137). Flatwoods.

TRILISIA ODORATISSIMA, Cass. Myers and Marco (169. Flatwoods.

CHRYSOPSIS ARGENTEA, Ell. Myers, Marco (138). Flatwoods.

APLOPAPPUS RUBIGINOSUS, T. & G. var. *Phyllocephalus*, Gray. Sanibel, Punta Rassa (174). Along the seashore, near the mangroves.

BIGELOVIA NUDATA, DC. Myers. Around ponds.

SOLIDAGO SEMPERVIRENS, L. Myers (168). Near ponds in flatwoods.

SOLIDAGO CHAPMANI, Gray. Marco, Myers (167). Flatwoods, chiefly near ponds, among the rank palmettos.

SERICOCARPUS TORTIFOLIUS, Nees. Myers (165). Flatwoods.

ASTER CAROLINIANUS, Walt. Myers. Along river, in thickets.

ASTER ADNATUS, Nutt. Myers. Flatwoods.

ASTER SUBULATUS, Michx. Myers.

ERIGERON NUDICAULIS, Michx. Myers (143). Wet-weather ponds in flatwoods.

ERIGERON QUERCIFOLIUS, Lam. Myers, Sanibel (145). Old sandy fields.

ERIGERON CANADENSIS, L. Sanibel, Marco, Myers (144). A weed in waste places.

BACCHARIS GLOMERULIFLORA, Pers. Marco. Brackish marsh.

BACCHARIS ANGUSTIFOLIA, Michx. Myers (131), Marco (132). Brackish or salt marshes. A shrub four to six feet.

PLUCHEA BIFRONS, DC. Marco, Myers (161). Flatwood ponds.

PLUCHEA IMBRICATA, Nash. Myers (162). Along ditch, in flatwoods. In the fields this has so different an aspect that I think it is entitled to rank as a species.

PLUCHEA CAMPHORATA, DC. Marco, Myers (160). Margins of ponds and rivers.

PTEROCAULON PYCNOSTACHYON, Ell. Marco, Myers (163). Flatwoods.

GNAPHALIUM PURPUREUM, L. Alva. Open, sandy soil.

SILPHIUM ASTERISCUS, L. Myers (166). Thickets in rich soil. This is the same as Simpson's specimen from Palma Sola and does not appear to be this species.

BERLANDIERA SUBACAULIS, Nutt. Myers (134). Flatwoods.

IVA IMBRICATA, Walt. Punta Rassa (152). Seashore, in open ground.

IVA FRUTESCENS, L. Myers (153). Salt marshes. A tall shrub, as much as fifteen feet.

IVA MICROCEPHALA, Nutt. Myers.

AMBROSIA ARTEMISIÆFOLIA, L. Marco, Punta Rassa, Myers (130). A weed in waste places.

XANTHIUM sp. (Presumably *X. strumarium*, L. Myers. A street weed.

ECLIPTA ALBA, Hook. Myers (140). Ditches.

MELANTHERA HASTATA, Michx. Marco, Sanibel, Myers (157). In thickets around flatwood ponds.

RUDBECKIA HIRTA, L. Myers (164). Margins of flatwood ponds, in thickets.

BORRICHIA FRUTESCENS, DC. Myers, Marco, Punta Rassa (136). Salt flats near mangroves.

HELIANTHELLA GRANDIFLORA, T. & G. Myers. Flatwoods.

VERBESINA VIRGINICA, L. Sanibel, Marco, Punta Rassa (170). Seashore, in openings in the thickets.

COREOPSIS LEAVENWORTHII, T. & G. Sanibel, Myers (139). Margins of flatwood ponds.

BIDENS LEUCANTHA, Willd. Marco, Myers (135). A weed in waste places.

BALDWINIA MULTIFLORA, Nutt. Myers (133). Flatwoods.

POLYPTERIS INTEGRIFOLIA, Nutt. Myers.

PALAFOXIA FEAYI, Gray. Marco (159). Flatwoods.

FLAVERIA LINEARIS, Lag. Sanibel.

PECTIS CILIARIS, L. Marco (173). Open ground, shell mounds. Plant prostrate, lemon scented.

ERECHTITES HIERACIFOLIA, Raf. Myers (142). A weed in waste places.

CNICUS HORRIDULUS, Pursh. Punta Rassa, Sanibel, Myers Open ground on seacoast.

CNICUS NUTTALLII, Gray. Myers.

HIERACIUM GRONOVII, L. Myers (151). Flatwoods. Scattered, but frequent.

LYGODESMIA APHYLLA, DC. Myers (156). Flatwoods.

LACTUCA CANADENSIS, L. Alva, Marco. Hammock land. This does not seem to be that species but I cannot place it elsewhere.

SONCHUS OLERACEA, L. Myers, Marco. A weed along streets.

SCÆVOLA PLUMIERI. Vahl. Sanibel, Punta Rassa (187). Seashore, mostly between the dune thickets and the water, Dense round-topped shrubs about two feet high.

LOBELIA GLADULOSA, Walt. Myers. Flatwoods in moist places.

LOBELIA PALUDOSA, Nutt. Myers (188). Margin of flatwood ponds.

LOBELIA CLIFFORTIANA, L. var. *Xalapensis*, Gray. Myers.

LOBELIA FEAYANA, Gray. Myers (189). Along flatwood ponds in the open ground inside of the palmettos.

VACCINIUM ARBORIUM, Michx. Alva (192). Palmetto hammock. Tall shrub.

VACINNIUM NITIDUM, Andr. Myers, Marco. Flatwoods. Shrubs about a foot high.

VACCINIUM CUBENSE, Griseb. Myers.

ANDROMEDA NITIDA, Bartr. Alva and Myers (191.) Along streams. Shrub four to seven feet.

ANDROMEDA FRUTICOSA, Myers (190), Marco. Flatwoods Common. A shrub two to six feet high.

BEJARIA RACEMOSA, Vent. Myers (193). Flatwoods. Shrub three to four feet high, called "catch-fly" on account of the sticky glands around the calyx and pedicels.

STATICE CAROLINIANA, Walt. Myers (194). Salt marshes.

SAMOLUS FLORIBUNDUS, HBK. Myers (196). Brackish marsh.

SAMOLUS EBRACTEATUS, HBK. Sanibel (195). Salt marshes.

MYRSINE RAPANA, R. & S. Myers (198). Marco. Hammocks near marsh. Small tree, eight to ten feet.

ARDISIA PICKERINGIA, T. & G. Myers (197), Marco. Hammock near brackish marsh.

JACQUINIA ARMILLARIS, L. Punta Rassa. Dune thickets.

BUMELIA LANUGINOSA, Pers. Marco. Thickets.

BUMELIA RECLINATA, Gray. Myers (199). Common in the vicinity of swamps. Forms little clumps or thickets two to six feet high, very prickly.

BUMELIA CUNEATA, Sw. Punta Rassa, Myers, Marco. A common shrub in the dune thickets along the seashore.

SIDEROXYLON MASTICHODENDRON, Jacq. Marco, Myers (200). Hammocks near seashore, a large tree.

DIOSPYROS VIRGINIANA, L. Myers. Along river and in swamp thickets.

FRAXINUS EPIPTERA, Michx. Myers. Cypress swamps.

FRAXINUS CUBENSIS, Griseb. Alva (201). Along the bank of the Caloosahatchee. Simpson's No. 18 from Manatee is this.

FORESTIERA PORULOSA, Poir. Punta Rassa. Thickets along dunes.

VINCA ROSEA, L. Myers (203). Streets and waste places. Escaped from cultivation. Flowers white or pink.

ECHITES PALUDOSA, Vahl. Myers (202), Marco. Climbing on shrubs and grasses in salt marshes.

PHILIBERTIA VIMINALIS, Gray. Myers (207). Hammock near salt marshes. Climbing over shrubs and small trees.

PODOSTIGMA PUBESCENS, Ell. Myers (206), Marco. Flatwoods.

ASCLEPIAS PAUPERCULA, Michx. Myers (210). Around flatwood ponds, in edge of palmettos.

ASCLEPIAS TOMENTOSA, L. Marco.

ASCLEPIAS VERTICILLATA, L. Myers and Sanibel (208). Moist places in flatwoods. At Sanibel, on the sandy prairies.

ASCLEPIAS FEAYI, Gray. Myers (209). Flatwoods.

ACERATES LONGIFOLIA, Ell. Myers (211). Flatwoods.

SEUTERA MARITIMA, DC. Sanibel (205), Myers, Marco. Salt marshes.

VINCETOXICUM SCOPARIUM, Gray. Marco (204). Near mangrove swamps, climbing on shrubs, forming a dense mass.

GONOLOBUS SUBEROSA, R. Br. Myers.

MITREOLA PETIOLATA, T. & G. Myers (212). Open ground around flatwood ponds.

MITREOLA SESSILIFLORIA, T. & G. Myers and Alva (213). A narrow-leaved form. Myers (214). Around flatwood ponds, near the water.

MITREOLA ANGUSTIFOLIA, T. & G. Myers, Sanibel. Around flatwood ponds.

POLYPREMUM PROCUMBENS, L. Myers (215). Flatwoods. Very common.

SABBATIA GRACILIS, Salisb. Myers (218). Marco. Wet-weather ponds, in flatwoods. var. *Grandiflora*, Gray. Myers (217). Wet-weather ponds in flatwoods.

SABBATIA ELLIOTTII, Steud. Myers (216). Marco. Flat-woods.

SABBATIA CHLOROIDES, Pursh. Myers.

LIMNANTHEMUM TRACHYSPERMUM, Gray, Myers (219). Permanent ponds.

HYDROLEA CORYMBOSA, Ell. Myers (220). Open ground around flatwood ponds.

HELIOTROPIUM POLYPHYLLUM, Lehm. Myers, Sanibel (221), Punta Rassa (222), Open ground or prairie along the coast. Flowers white but in dried specimens appearing yellow.

HELIOTROPIUM PARVIFLORUM, L. Myers (223), Marco (224), Sanibel. Along a ditch at Myers (223); shell mounds at Marco (224).

IPOMOEA BONA-NOX, L. Marco (225), Myers (226), Sanibel. Climbing on shrubs in moist thickets.

IPOMOEA HEDERACEA, Jacq. var. *Integriuscula*, Gray. Marco (227). Along the edge of field. Seems quite distinct in aspect from *I. Hederacea*. Climbing stems long and stout.

IPOMOEA CATHARTICA, Poir. Punta Rassa (228), Sanibel (229), Everglade, Marco. Sand dunes along the coast. Climbing on shrubs.

IPOMOEA PES-CAPRÆ, Sweet. Myers (230), Marco. Mucky soil along Caloosahatchee at Myers (No. 230). Is a trailing strand plant along the coast.

Ipomoea Sagittata, Cav. Myers (231), Marco. Salt marshes.

Evolvulus Sericeus, Sw. Sanibel. Sandy prairies.

Breweria Aquatica, Gray. Punta Rassa (233). Open ground along the coast.

Cuscuta Obtusiflora, HBK. var. *Glandulosa*, Englm. Myers (232). Climbing on shrubs and tall herbs in permanent ponds. Mostly on *Cephalanthus*.

Slonanum Nigrum, L. Myers (239). A weed in cultivated ground and waste places.

Solanum Bahamense, L. Everglade.

Solanum Aculeatissimum, L. Myers (240). A weed of waste ground and along streets.

Physalis Angulata, L. Myers (238). A weed in fields. Annual.

Physalis Elliotii, Kuntze. Marco (237), Sanibel, Punta Rassa. Along seacoast. Perennial.

Physalis Barbadensis, Jacq. Marco (235), Myers (236. A weed. Old field at Myers, on shell mounds at Marco. An annual.

Phylalis Ciliosa, Ryd. Myers, 234. A weed in cultivated fields. Perennial.

Physalis Macropbysa, Ryd. Everglade. A weed in cultivated soil.

Capsicum Frutescens, L. Myers, Punta Rassa, Marco (242). Along seacoast in thickets.

Capsicum Frutescens, L. Myers (243). Escaped. Found two patches along roadside in town.

Lycium Carolinianum, Michx. Myers (241), Marco, Punta Rassa, Sanibel. Salt marshes and mangrove swamps. A shrub eight to fifteen feet high.

Pentstemon Lævigatus, Sol. Alva (247), Myers. Ditches and along edges of hammocks.

Herpestis Nigrescens, Benth. Alva (250), Myers. Along ditches.

Herpestis Amplexicaulis, HBK. Myers, (249). Margin of flatwood ponds.

HERPESTIS MONNIERA, HBK. Myers (251), Marco. Muddy shores of ponds and streams.

GRATIOLA PILOSA, Michx. Myers (258). Wet-weather ponds in flatwoods. Flowers pale yellow. Stem smooth. Otherwise like the usual form.

GRATIOLA SUBULATA, Baldw. Myers (246), Marco. Flatwoods.

ILYSANTHES GRANDIFLORA, Benth. Myers (252). Wet-weather ponds in flatwoods.

MICRANTHEMUM NUTTALLII, Gray. Myers (253). Wet sand in open ground, among grass, near river.

SCOPARIA DULCIS, L. Myers (248). Along the streams and in waste places; two to three feet high; woody at the base.

CAPRARIA BIFLORA, L. Myers (255). Waste places.

BUCHNERA ELONGATA, Sw. One form has purple corolla. Myers (256), Marco, Sanibel. Another has nearly white corolla twice as broad. Myers (257).

SEYMERIA PECTINATA, Benth. Marco (254). Flatwoods.

GERARDIA LINIFOLIA, Nutt. Myers.

GERARDIA PURPUREA, L. var. *Fasciculata*, Chapm. Sanibel.

GERARDIA MARITIMA, Raf. Sanibel (245), Marco. Salt marshes.

GERARDIA SKINNERIANA, Wood. Marco, Myers (244). Flatwoods.

UTRICULARIA OLIGOSPERMA, St. Hil. Myers. Permanent ponds.

UTRICULARIA RESUPINATA, Greene. Myers (264). Ponds in flatwoods, growing in the water. Corolla purple.

UTRICULARIA SUBULATA, L. Myers (263). Flatwood ponds, growing in the water.

UTRICULARIA CORNUTA, Michx. Myers (262). Wet-weather ponds in flatwoods, growing in the water.

UTRICULARIA STRIATA, Leconte. Myers (265). In an abandoned well, floating on the surface in a dense mat.

ELYTRARIA VIRGATA, Michx. Myers (260). Openings in thickets near ponds in flatwoods.

CALOPHANES OBLONGIFOLIA, Don. Myers.

JELLIA CILIOSA, Pursh. Myers (261). Shady places in hammocks.

'ENANDRIUM DULCE, Nees. var. *Floridanum*, Gray. Myers (259). Openings in thickets near ponds.

:OLEPTERA ASSURGENS, Juss. Everglade, Myers.

:ACHYTARPHETA JAMAICENSIS, Vahl. Myers (273), Marco. A weed in waste places.

ERBENA URTICÆFOLIA, L. Myers (269). Moist ground along the river.

IPPIA NODIFLORA, Michx. Myers (271), Sanibel. Margins of rivers and ponds.

ANTANA INVOLUCRATA, L. Marco, (267). Shell mounds. Shrub two to three feet high. Flowers white or greenish.

ANTANA CAMARA, L. Myers (266), Punta Rassa (268). Escaped along streets and in moist places at Myers (No. 266). Along seacoast at Punta Rassa, apparently indigenous (No. 268). Shrubs three to four feet high. Flowers pink, with yellow eye.

ALLICARPA AMERICANA L. Myers (272). Thickets along hammocks and river banks.

VICENNIA NITIDA, Jacq. Myers (270), Punta Rassa, Sanibel, Marco. Swamp forests along the coast, usually associated with mangroves.

RICHOSTEMA LINEARE, Nutt Myers (279), Punta Rassa. Moist sand among the saw palmettos.

EUCRIUM NASHII, Kearney. Myers (281). Hammock near river.

YPTIS RADIATA, Willd. Myers (274). Margin of ponds.

YPTIS SPICIGERA, Lam. Myers. A weed in waste places

ENTHA VIRIDIS, L. Myers. Along street.

.TUREIA RIGIDA, Bartr. Alva (280), Myers. Flatwoods.

.LVIA LYRATA, L. Myers (276). Open shady places in hammocks.

ONARDA PUNCTATA, L. var. *Leucantha*, Nash. Punta Rassa (275), Marco. Sand dunes along coast. A bushy branched plant about three feet high. The same as Nash 2456 from Palmetto, but I think it is distinct from *M. punctata*.

SCUTELLARIA ARENICOLA, Small. Myers (274).

SCUTELLARIA INTEGRIFOLIA, L. var. *Hyssopifolia*. Myers and Alva (278). Flatwoods.

PHYSOSTEGIA DENTICULATA, Britt. Myers (282). Along the border of ponds, in flatwoods among the palmettos.

PLANTAGO LANCEOLATA, L. Myers. A weed in waste places.

MIRABILIS JALAPA, L. Everglade. Probably escaped from cultivation.

BOERHAAVIA HIRSUTA, Willd. Sanibel, Punta Rassa, Marco (283). Shell mounds (No. 283), and sandy prairies. Perennial from woody tap-root.

BOERHAAVIA ERECTA, L. Punta Rassa (284), Myers. Open, sandy ground along coast; at Myers a single plant as a weed in a cultivated field. Forms a spindle-shaped, fleshy tap-root, perennial.

SIPHONYCHIA AMERICANA. T. & G. Alva (285). In an old field.

SUEDA LINEARIS, Moq. Myers and Punta Rassa (286), Sanibel, Marco. Salt marshes.

ATRIPLEX CRISTATA, HBK. Punta Rassa (287), Marco, Sanibel. Along seashore.

SALICORNIA AMBIGUA, Punta Rassa (288), Marco. Mangrove swamps.

CHENOPODIUM ANTHELMINTICUM, L. Myers (289). A weed in fields and waste places.

CHENOPODIUM sp. Marco (290), (291). Shell mounds and open ground near seashore, allied to *C. album*. Probably the same form. Sanibel, Myers.

AMARANTUS HYBRIDUS, L. Sanibel (292), Marco, Myers, Punta Rassa. A weed in fields.

AMARANTUS SPINOSUS, L. Myers (293), Marco. A weed along streets and in waste places.

EUXOLUS LIVIDUS, Moq. Myers (298), Marco, Punta Rassa. A weed in waste places.

ACNIDA AUSTRALIS, Gray. Myers (299). Brackish marsh. Plant five to ten feet high with an enlarged strong base the shape of cypress trunk.

ACNIDA TAMARASCINA, Wood. var. *prostrata*, U. & B. Sanibel. Sandy prairie. Curtiss. No. 2373 belongs here.

IRESINE VERMICULARIS, Moq. Marco (300), Myers, Sanibel. Muddy seashore.

IRESINE CELOSIOIDES, L. Myers (294), Sanibel (295), Marco. Hammock (No. 294); sandy prairies (No. 295); shell mounds at Marco.

TELANTHERA FLORIDANA, Moq. Marco (296), Sanibel (297). Margins of Mangrove swamp.

RIVINA HUMILIS, L. Myers (302), Sanibel. Hammocks.

PHYTOLACCA DECANDRA, L. Myers 301), Marco, Punta Rassa. A weed in waste places.

BATIS MARITIMA, L. Punta Rassa (303), Sanibel. Mangrove swamps.

RUMEX CRISPUS, L. Myers. A weed in yards.

RUMEX FLORIDANUS, Meisn. Alva (307), Myers. Along a ditch, growing in the water.

POLYGONELLA PARVIFOLIA, Michx. Marco, Alva (308), Myers (309). Flatwoods.

POLYGONUM HYDROPIPEROIDES, Michx. Myers (305). Margin of ponds.

POLYGONUM PERSICARIA, L. Myers (306). A weed in a cultivated field. Seen in but one locality.

COCCOLOBA UVIFERA, Myers (304), Marco. Thickets along the seashore. A shrub or small tree.

SAURURUS CERNUUS, L. Myers. Fresh water swamps.

PERSEA CAROLINENSIS, Nees. Marco, Myers (310). Margin of ponds.

CASSYTHA FILIFORMIS, Mill. Myers (311), Marco. Climbing on shrubs in flatwoods.

EUPHORBIA POLYPHYLLA, Englem. Myers (323), Marco. Flatwoods.

EUPHORBIA HETEROPHYLLA, L. Sanibel (322), Marco. A weed in waste places.

EUPHORBIA HYPERICIFOLIA, L. Myers (324), Punta Rassa, Everglade. Along the streets and around habitations. Appears like an introduced plant.

EUPHORBIA BUXIFOLIA, Lam. Punta Rassa (325), Sanibel. Along strand.

EUPHORBIA PILULIFERA, L. Myers (326). Along streets.

STELLARIA ARENICOLA, Small. Myers (274).

STELLARIA INTEGRIFOLIA, L. var. *Hyssopifolia*. Myers and Alva (278). Flatwoods.

PHYSOSTEGIA DENTICULATA, Britt. Myers (282). Along the border of ponds, in flatwoods among the palmettos.

PLANTAGO LANCEOLATA, L. Myers. A weed in waste places.

MIRABILIS JALAPA, L. Everglade. Probably escaped from cultivation.

BOERHAAVIA HIRSUTA, Willd. Sanibel, Punta Rassa, Marco (283). Shell mounds (No. 283), and sandy prairies. Perennial from woody tap-root.

BOERHAAVIA ERECTA, L. Punta Rassa (284), Myers. Open, sandy ground along coast; at Myers a single plant as a weed in a cultivated field. Forms a spindle-shaped, fleshy tap-root, perennial.

SIPHONYCHIA AMERICANA. T. & G. Alva (285). In an old field.

SUEDA LINEARIS, Moq. Myers and Punta Rassa (286), San ibel, Marco. Salt marshes.

ATRIPLEX CRISTATA, HBK. Punta Rassa (287), Marco, San ibel. Along seashore.

SALICORNIA AMBIGUA, Punta Rassa (288), Marco. Mangr swamps.

CHENOPODIUM ANTHELMINTICUM, L. Myers (289). A in fields and waste places.

CHENOPODIUM sp. Marco (290), (291). Shell moun open ground near seashore, allied to C. *album* ably the same form. Sanibel, Myers.

AMARANTUS HYBRIDUS, L. Sanibel (292) Punta Rassa. A weed in fields.

AMARANTUS SPINOSUS, L. Myers along streets and in waste pl

EUXOLUS LIVIDUS, Moq. Myer A weed in waste places.

ACNIDA AUSTRALIS, Gray. Plant five to ten base the shape of

ACNIDA TAMARASCIN ibel. Sandy

Var. PROCUMBENS, Boiss. Marco (327). Shell mounds around dwellings, especially along paths.

EUPHORBIA AMMANNIOIDES, HBK. Punta Rassa (320). Openings in thickets along the seashore.

EUPHORBIA PROSTRATA, Ait. Marco (318). Shell mounds along paths and roads.

EUPHORBIA CORDIFOLIA, Myers (319), Punta Rassa, Sanibel, Marco. A weed in sandy fields.

EUPHORBIA MACULATA. Alva (328). This is not this species as found in Kansas, but comes nearest to this of any in the collection.

EUPHORBIA INNUNDATA, Torr. Myers (321). Flatwoods. No. 321 was growing in the water in a wet-weather pond.

STILLINGIA SYLVATICA, L. Myers (330), Sanibel. Open ground around pond. Leaves linear or linear lanceolata.

ACALYPHA GRACILENS, Gray. Myers (313). Shady places along streets.

ACALYPHA CAROLINIANA, Walt. Myers (312). Waste places in town.

TRAGIA LINEARIFOLIA, Ell. Myers (331). A weed in cultivated fields, also in flatwoods.

CROTON GLANDULOSUS, L. Myers (316), Punta Rassa (317). Open sandy places. No. 317 along the coast.

Var. MARITIMUS, Walt. Sanibel, Punta Rassa (315). Seacoast on the strand.

CNIDOSCULUS STIMULOSUS, Gray. Myers (314), Marco. Flatwoods.

RICINUS COMMUNIS, L. Myers. Waste places.

PHYLLANTHUS CAROLINIANUS, Walt. Punta Rassa (329), Sanibel. Along strand.

PILEA MUSCOSA, Lindl. Marco (334). Shell mounds under the piazza of the hotel.

BOEHMERIA CYLINDRICA, Willd. Myers. Shady places.

Var. SCABRA, Port. Myers (333). Ditches.

MORUS RUBRA, L. Myers. Hammocks.

FICUS AUREA, Nutt. Myers.

'ICUS BREVIFOLIA, Nutt. Myers (332). Hammock near river.

IYRICA CERIFERA, L. Myers (335), Marco. Bayheads and swamps.

'ARYA AQUATICA, Nutt. Alva (336). Along the river bank.

UERCUS AQUATICA, Walt. Myers (339). Hammocks.

UERCUS MYRTIFOLIA, Willd. Myers, Marco. Flatwood thickets.

UERCUS PARVIFOLIA, Small. Marco, Myers (340). Flatwoods. A shrub two to three feet high.

UERCUS VIRENS, Ait. Alva (337), Marco. Thickets in flatwoods. A shrub two to five feet high.

Var. SPICATA. Myers.

UERCUS MARITIMA, Willd. Myers, Marco, Punta Rassa. Dune thickets along coast.

UERCUS NANA, Willd. Myers (338). Flatwoods. A shrub about one foot high. This seems to be *Q. virens dentata* of Chapman's flora.

ALIX NIGRA WARDI, Bebb. Myers. Bayheads.

ERATIOLA ERICOIDES, Michx. Marco. White sand scrub forming a ridge in the flatwoods south of the town on Marco Island. The only place I observed the plant in Lee county.

ERATOPHYLLUM DEMERSUM, L. Myers (339). Shallow water in the Caloosahatchee river.

ALISNERIA SPIRALIS, L. Myers (376). Caloosahatchee.

PTERA SETACEA, Nutt. Myers. In a sphagnum bog.

PIDENDRUM TAMPENSE, Lindl. Marco, Sanibel, Myers (240). In salt marsh thickets growing on various shrubs or small trees.

'RTOPODIUM WOODFORDII, Lindl. (?) Myers.

ALOPOGON PARVIFLORUS, Lindl. Myers. Ponds in the flatwoods.

ABENARIA NIVEA, Spreng. Myers.

ABENARIA MICHAUXII, Nutt. Myers (341), Alva, Marco. Moist places in the flatwoods.

'IRANTHES GRACILIS, Bigel. Myers, Sanibel. Stem is eighteen inches high, growing in the water. Lowest

[illegible] Sanibel.

[illegible] palmetto [illegible]

[illegible] Myers (345). Epiphytic [illegible]

Tillandsia usneoides, L. Myers (345), Marco. Hanging from trees in hammocks and swamps.

Lachnanthes tinctoria, Ell. Myers (350). Swamps and ditches.

Aletris farinosa, L. Myers. Flatwoods.

Smilax [illegible], L. Myers.

Smilax Bona-nox, L. Myers (352). Hammocks.

Smilax auriculata, Walt. Punta Rassa and Alva (45). Climbing over dune thickets at Punta Rassa and in palmetto hammocks at Alva.

[illegible] Walt. Myers.

[illegible], L. Myers, Marco. Flatwoods; shell mounds at Marco.

AMIANTHIUM ANGUSTIFOLIUM, Gray. Myers. Ponds and depressions in flatwoods.

PONTEDERA CORDATA, L. Myers (354). Ponds and swamps.

EICHORNIA CRASSIPES, Solms. Myers (304). Abundant in Caloosahatchee river and tributary streams. Water hyacinth.

XYRIS BREVIFOLIA, Michx. Myers.

XYRIS ELATA, Chapm. Marco.

XYRIS AMBIGUA, Beyr. Marco, Alva, Myers (360). Flatwood ponds. Flowers yellow.

XYRIS PLATYLEPIS, Chapm. Myers (359). Ditches and swamps. Grows in bunches. Flowers yellow.

XYRIS TORTA, Smith. Myers (358). Flatwoods. Flowers white. Plants solitary.

XYRIS BALDWINIANA, R. & S. Myers (357). Wet-weather ponds in flatwoods. Grows in clumps. Flowers yellow.

COMMELYNA NUDIFLORA, L. Myers (364). Along river bank.

COMMELYNA ERECTA, L Myers (363), Punta Rassa. A weed in fields. Forms large bunches.

TRADESCANTIA FLORIDANA, Wats. Myers (361). On little hillocks in hammock, forming a mat over the ground.

TRADESCANTIA ROSEA, Vent. Myers (362), Marco. Flatwoods.

JUNCUS EFFUSUS, L. Marco.

JUNCUS SCIRPOIDES, Lam. Myers (367). Flatwood ponds

JUNCUS ELLIOTTII, Chapm. Alva (365). Flatwoods.

JUNCUS MARGINATUS, Rostk. Myers (366). Flatwood ponds.

SAGITTARIA LANCIFOLIA, L. var. *Falcata*, Smith. Myers. Ponds.

SAGITTARIA GRAMINEA, Michx. Myers.

Var. CYCLOPTERA, Smith. Myers (371.) Flatwood ponds, in the water or along the margin.

SAGITTARIA SUBULATA, Buch. var. *Natans*, Smith. Myers (370). Permanent ponds. Leaves and fruit submerged. Flowers at surface. When the flowers are drawn beneath the surface a bubble of air remains inside the petals and the polen is not injured.

TRIGLOCHIN TRIANDRA, Michx. Myers (372.) Salt marshes.

RUPPIA MARITIMA, L. Myers. Caloosahatche river.

ZANNICHELLA PALUSTRIS, L. Myers. Caloosahatchee river.

SABAL PALMETTO, R. & S. Myers (369). Along river and brackish salt marshes. Flat, marshy land covered with palmetto is called palmetto flat, or palmetto slough, if a bayou or inlet. Richer land along the river upon which palmettos are found forms a palmetto hammock. Cabbage palmetto.

SERENOA SERRULATA, Hook. f. Myers (368), Marco, Punta Rassa. Common in flatwoods throughout this region. Along river banks, ponds, and swamps the growth is much more rank and the leaves may be as much as five feet high. Saw palmetto.

TYPHA ANGUSTIFOLIA, L. Myers. Swamps and river banks.

ARISAEMA TRIPHYLLUM, Torr. Myers. Marshes, and frequent in a sphagnum bog.

PISTIA SPATHULATA, Michx. Myers. Caloosahatchee river; called water lettuce.

LEMNA MINOR, L. Myers (373). Floating in permanent ponds.

ERIOCAULON DECANGULARE, L. Myers (375). Ponds where the water is present for a considerable portion of the year.

PAEPLANTHUS FLAVIDULUS, Kunth. Myers, Marco. Wet-weather ponds in flatwoods.

LACHNOCAULON GLABRUM, Korn. Myers (374). Wet-weather ponds in flatwoods.

CYPERUS LEUCOLEPIS, Carey. Myers (398). New soil in open ground near river.

CYPERUS NUTTALLII, Torr. Myers (392), (393), Marco. Around flatwood ponds (No. 392) and common in fields and moist places. Also brackish marshes (No. 393).

CYPERUS MICRODONTUS, Torr. Alva, Myers.

CYPERUS STRIGOSUS, L. Myers (391). Swamps and ditches.

CYPERUS BRUNNEUS, Sw. Sanibel, Marco (395),(396). Shell mounds near the water at Marco.

CYPERUS TETRAGONUS, Ell. Myers (389), Marco (390). Hammock (No. 389.) Prairie near mangrove swamp No. (390).

CYPERUS LIGULARIS, L. Marco, Punta Rassa (394). Along the coast.

CYPERUS SPECIOSUS, Vahl. Myers (388). Swamps and ditches.

CYPERUS ESCULENTUS, L. Myers (387). A weed in fields.

CYPERUS HASPAN, L. Myers (280). Around flatwood ponds.

CYPERUS CALCARATUS, Nees. Myers (385) Marshes and ditches.

CYPERUS COMPRESSUS, L. Myers (397). A weed in fields.

CYPERUS BALDWINII, Torr. Alva (381), Myers (383), Marco. Sandy hammocks (No. 381), and also a weed in fields (No. 382).

CYPERUS CYLINDRICUS, Britt. Myers (384). Around flatwood ponds and in fields.

CYPERUS CYLINDROSTACHYS, Boeckl. Marco (383), Sanibel, Punta Rassa, Myers. Prairie near mangrove swamps.

KYLLINGIA PUMILA, Michx. Myers (414). Ditches, and moist places in flatwoods.

KYLLINGIA BREVIFOLIA, Rottb. Myers (413). Open, grassy land in flatwoods.

HEMICARPHA SUBSQUARROSA, Nees. Myers (436). Around flatwood ponds.

FUIRENA SCIRPOIDEA, Vahl. Myers, Marco. Around ponds

FUIRENA SQUARROSA, Michx. Myers (412). Bayheads and ponds.

ELEOCHARIS CELLULOSA, Torr. Myers (403). Brackish marsh.

ELEOCHARIS OCHREATA, Nees. Myers (402), Marco. Muddy soil near salt marshes (No. 402).

ELEOCHARIS CHÆTARIA, R. & S. Alva (401), Myers. Moist places in flatwoods.

ELEOCHARIS MICROCARPA, Torr. Myers, Sanibel.

FRIMBRISTYLIS CASTANEA, Vahl. Myers (410), Marco (411), Punta Rassa, Sanibel. . Around flatwood ponds. No. 411 in a prairie, near mangrove swamp.

FRIMBRISTYLIS SPADICEA, Vahl. Sanibel (404), Myers, Marco, Salt marshes.

FRIMBRISTYLIS PUBERULA, Vahl. Myers (408), (409). Flat-woods; No. 409 was a weed in an orange grove. Grows in bunches; no rhizomes.

FRIMBRISTYLIS LAXA, Vahl. Alva.

FRIMBRISTYLIS AUTUMNALIS, R. & S. Myers (406), (40 Marco. Around flatwood ponds.

STENOPHYLLUS CAPILLARIS, Britt. Myers (405), (411). Pun Rassa. Flatwoods.

STENOPHYLLUS WAREI, Britt. Myers (434). Flatwoods.

STENOPHYLLUS STENOPHYLLUS, Britt. Myers (435). Flat-woods.

RHYNCHOSPORA CYPEROIDES, Mart. Myers (418). Flatwood ponds, growing in water.

RHYNCHOSPORA PATULA, Gray. Myers (426). Margin of cypress swamp.

RHYNCHOSPORA DIVERGENS, Chapm. Myers.

RHYNCHOSPORA INTERMEDIA, Britt. Myers, Marco, Alva (427). Flatwoods.

RHYNCHOSPORA FILIFOLIA, Gray. Myers.

RHYNCHOSPORA FASCICULARIS, Vahl. Myers (423), (424), (549). Ponds and ditches, in flatwoods.

RHYNCHOSPORA DODECANDRA, Baldw. Marco, Alva (417). Flatwoods.

RHYNCHOSPORA CYMOSA, Nutt. Myers (425). Around ponds and flatwoods.

RHYNCHOSPORA MICROCARPA, Baldw. Myers (421), Marco. Ponds in flatwoods.

RHYNCHOSPORA CADUCA, Ell. Alva, Myers (422). Swamps and ditches.

RHYNCHOSPORA MILACEA, Gray. Myers (420). Sphagnum bog.

RHYNCHOSPORA STIPATA, Chapm. Myers (419). Flatwood ponds.

CHÆTOSPORA NIGRICANS, Kunth. Myers (379). Flatwoods, near pond.

PSILOCARYA NITENS, Ward. Myers (415), (416). Bogs and wet places in flatwoods.

DICHROMENA LEUCOCEPHALA, Michx. Myers (400), Marco. Around flatwood ponds.

DICHROMENA LATIFOLIA, Baldw. Myers (399). Flatwood ponds, in water.

CLADIUM EFFUSUM, Torr. Myers and Sanibel (380), Marco. Ponds and marshes. Saw-grass.

SCLERIA Sp. Myers (433). Along a ditch. Culms filiform, a foot or two high. Rootstock knotty, creeping. Leaves narrow, almost filiform. Flowers one or two. Nutlets reticulated.

SCLERIA VERTICELLATA, Muhl. Myers.

SCLERIA TRIGLOMERATA, Michx. Alva (431). In an old field.

SCLERIA OLIGANTHA, Ell. Myers (432). Wet places in flatwoods.

SCLERIA LAXA, Torr. Myers (428). Along a ditch.

SCLERIA BALDWINII, Torr. Myers (430). Growing in water in flatwood pond.

SCLERIA FILIFORMIS, Sw. Myers (429). Growing in water in flatwood pond.

CAREX ALBOLUTESCENS, Schwein. Myers.

CAREX GIGANTEA, Rudge. Alva (378). Along river bank, growing in the water.

REIMARIA OLIGOSTACHYA, Munro. Myers, Sanibel.

PASPALUM PLATYCAULON, Poir. Myers (502), (503). Alva. Swamps and ditches. Also in mud along streets (No. 503). Forms long runners.

PASPALUM PASPALOIDES, Scrib. Alva, Myers (504). Flatwood ponds. Grows in or near the water. Forms long runners.

PASPALUM DISTICHUM, L. Myers (506). Sanibel. A common weed in fields, where it is exceedingly troublesome on account of the rooting runners which may extend several feet. Called there "Thompson grass" or "Fort Thompson grass." It is a valuable forage grass.

PANICUM VAGINATUM, Sw. Myers (505). Meadows near salt marshes.

PASPALUM CILIATIFOLIUM, Michx. Sanibel, Marco, Punta Rassa, Myers (507). A weed in fields. This and the two preceding are also found in the flatwoods, but

usually small plants with only one to a few flowering culms.

PASPALAM SETACEUM, Michx. Myers (509). A weed in fields, growing in large bunches.

PASPALUM LONGIPEDUNCULATUM, LeConte. Marco, Myers (508). A weed in fields. Grows in large bunches.

PASPALUM RACEMULOSUM, Nutt. Myers.

PASPALUM PRÆCOX, Walt. Myers (499), (500), (501). Swamps and along ponds and bayheads.

PASPALUM GIGANTEUM, Baldw. Myers.

PASPALUM FLUITANS, Kunth. Myers. Ponds, floating on the surface.

ERIOCHLOA MOLLIS, Kunth. Sanibel (464). Sandy prairies.

ERIOCHLOA LONGIFOLIA, Vasey. Myers (462). Marco (463). Around ponds. No. 463 along sandy seashore.

OPLISMENUS SETARIUS, R. & S. Myers (467). Hammocks in rich soil.

AMPHICARPUM FLORIDANUM, Chapm. Myers.

PANICUM SANGUINALE, L. Myers. Glumes very hairy or ciliate at the margins.

PANICUM FILIFORME, L. Sanibel, Myers (495), Alva (496), Marco (497). A weed in fields. No. 497 grew in large clumps about a yard in diameter.

PANICUM SETIGERUM, Roth. Marco, Myers (498). A weed in fields, rooting at the nodes.

PANICUM SEROTINUM, Trin. Myers (493), (494). Common. Along streets. (No. 493), and a weed in fields (No. 494).

PANICUM CHAPMANII, Vasey. Marco (487). Shell mounds at edge of thicket.

PANICUM FUSCUM, Sw. Marco (484). Everglade. A weed in fields.

PANICUM FASCICULATUM, Sw. Marco (485). Sanibel. A weed in fields.

PANICUM LEUCOPHAEUM, HBK. Everglade.

PANICUM PROLIFERUM, Lam. Myers (483). Sanibel. A weed in a wet orange grove.

Tilletea rotundata (Arth.) Massee.
Host.—*Panicum virgatum* L.

Specimens from Iowa.—Herb. Iowa State College, New Albin, L. H. Pammel. Herb. J. C. Arthur (type). Herb. Hume—(84) New Albin, L. H. Pammel.

Affected ovaries scarcely differ from unaffected, there is no swelling or other external mark which would indicate that they are affected.

Tilletia striæformis (West.) Fisch. de Waldh.
Host.—*Poa pratensis* L.; *Phlem pratense* L.; *Agrostis alba*.

Specimens from Iowa.—Herb. Iowa State College (120) (101) (102), Ames, L. H. Pammel; (121) (122), Ames, F. C. Stewart. Herb. Hume (50) Ames, G. W. Carver. Crypt. Dist. Iowa State College (3) (4) (5) Ames, G. W. Carver.

Tilletia subfusca N. Sp.
Host.—*Sporobolus neglectus* Nash.

Specimen from Iowa.—Type in the Ex. Herb. J. C. Arthur, collected at Spirit Lake by Dr. J. C. Arthur.

This species is altogether different from the two species described by Ellis (1) on Sporobolus, namely *T. asperifolia* and T. *montana*. Specimen No. 1895 Ell. & Ev. N. A. F. collected at Boise City, Mont. by Gustave Smith, was made by Massee, the type of a new species, *Tilletia mixta*. My species somewhat resembles Massee's, but differs from it in having smaller and lighter colored spores. Most of those examined and measured in Dr. Arthur's specimens were 14u and none were above 16u. The spores nearly always appear to be smooth and on a few only were small scattered spines found.

On these differences it has been provisionally described as a new species.'

Neovossia Körn, Oestr. Bot. Zeitschr. 29:217. 1879.

(1) Journal of Mycology 3:55. An. 1887.

PANICUM HISPIDUM, Forst. Myers (476), Sanibel. Swamps. No. 376 in an inundated cultivated field.

PANICUM COLONUM, L. Marco (475). A weed in the shell-mound fields.

PANICUM GIBBUM, Ell. Myers (486). Swamps and ditches.

PANICUM SP. Myers. This is the same as Nash No. 778.

SETARIA IMBERBIS, R. & S. Myers (511, 512, 513), Punta Rassa, Marco. A common seed. This is a large form with hair on the leaves. Myers (514), Sanibel (515), A small slender form growing in clumps. No hairs on leaves, near the ligules.

SETARIA CORRUGATA, Schult. Myers (516), Alva (517). A weed in fields. No. 517 along sandy river bank.

SETARIA MACROSPERMA, Scrib. & Merr. Myers (518). A weed in fields. Annual. Often from large bunches.

SETARIA SETOSA, Beauv. Marco (519). Shell mounds near water. Grows in large clumps.

CENCHRUS ECHINATUS, L. Myers (448). Marco. A weed in fields.

CENCHRUS TRIBULOIDES, L. Myers (447). Flatwoods and fields.

CENCHRUS INCERTUS, Curtiss. Punta Rassa (446). Sanibel. Along the coast.

STENOTAPHRUM AMERICANUM, Schrank. Myers (531). Marco, Punta Rassa. Along the streets of Myers and on mucky river bank. Cultivated as a lawn grass. Called St Augustine Grass.

LEERSIA HEXANDRA, Sw. Myers (468). Swamps.

ROTTBOELLIA RUGOSA, Nutt. Myers (510). Swampy flat, near pond.

TRIPSACUM DACTYLOIDES, L. Myers (534), Alva. Large clumps in ponds and bayheads.

ELIONURUS TRIPSACOIDES, HBK. Myers (456). Around flatwood ponds.

ANDROPOGON ELLIOTTII, Chapm. Punta Rassa (440), Myers. Open ground near coast.

ANDROPOGON LONGIBERBIS, Hack. *Forma macra*, Nash, 1194. Myers (441). Swamps and ditches.

ANDROPOGON VIRGINICUS, L. Alva (439). Old fields.

ANDROPOGON FLEXILIS, Bosc. Marco, Punta Rassa, Sanibel (438). Sandy prairies.

ANDROPOGON MACROURUS, Michx. Marco, Myers (437). Swamps and ditches.

HETEROPOGON ACUMINATUS, Trin. Alva (465). A weed in an orange grove.

SORGHUM HALAPENSE, Pers. Marco (521). Along edge of fields, in shell mounds.

SPOROBOLUS DOMINGENSIS, Kunth. Sanibel (528), Marco (529), (530). Everglade. Along seabeach.

SPOROBOLUS JUNCEUS, Kunth. Sanibel (525), Myers. Old sandy field (No. 525); also in flatwoods.

SPOROBOLUS INDICUS, Brown. Myers (524). A weed along streets. Called smut grass.

SPOROBOLUS VIRGINICUS, Kunth. Marco (526). A robust form two to three feet high, growing on sandy seacoast. Salt marshes. No. 526 is the same as Curtiss 5554. Myers (527), Sanibel.

ARISTIDA PAYULA, Chapm. Sanibel, Myers (445), Marco. Around ponds and swamps.

ARISTIDA PURPURASCENS, Poir. Nash 2424. Sanibel, Punta Rassa (443). Open ground near coast.

ARISTIDA PALUSTRIS, Vasey. Myers. Flatwoods.

ARISTIDA STRICTA, Michx. Myers (444). Flatwoods. The same occurs in fields, where the clumps are much larger.

ARISTIDA SPICIFORMIS, Ell. Myers (442), Marco. Flatwoods.

MUHLENBERGIA CAPILLARIS, Kunth. Sanibel (466). Sandy prairies.

PHLEUM PRATENSE, L. Myers. Probably escaped from cultivation.

SPARTINA JUNCEA, Willd. Marco (523), Sanibel. Salt marshes.

SPARTINA STRICTA, Roth. MARITIMA, Scribn. Marco (522). Seabeach.

Specimens from Iowa.—Herb. Iowa State Colle ge (120 Clinton, L. H. Pammel.

The spore masses are quite hard and so compact as to be easily sectioned. A cross section reveals the presence of a portion of the plant tissues among which may be seen, upon microscopical examination, the remains of the mycelium. From this the spores are arranged basipetally. Consequently it appears that this species belongs more properly to the genus *Cintractia*. In 1896 Dr. P. Mangus described *Cintractia Seymouriana* occuring on *Panicum crus-galli* but his fungus affected only the culms and leaves, and for this reason it appears to be different. So far as known the species under consideration affects only the ovaries. Hence this fungus occuring in the ovaries of *P. crus-galli* has been provisionally transferred to the genus Cintractia, as *Cintractia sphærogena* (Burrill.)

Cintractia Reiliana (Kuehn.) Clinton.

Host.—*Sorghum* sp. probably *vulgare*.

Specimens from Iowa.—Herb. Iowa State College (55,) Monticello, E. E. Reed.

The fibro-vascular bundles of the affected portion remain intact, serving as a sort of network in which the spores are held. The specimen from which the above description was drawn was collected in 1894 and is so far as known the only one ever taken in the state. It is probably more common than the number of specimens would indicate.

Tilletia Tul. Ann. Sci. Nat. Bot. 7:112. 1847.

Tilletia foetens Trelease.

Host.—*Triticum vulgare* L.

Specimens from Iowa.—Herb. Iowa State College (123) Ames, (124) (125) Ames, L. H. Pammel; Ex. Herb. J. C. Arthur (1776) Central Iowa, I. P. Roberts and A. N. Prentiss; Decorah, E. W. D. Holway. Herb. C. R. Ball, Ames, F. C. Stewart.

Though no description of this species was published by Berkeley and Curtiss until 1874, still specimen No. 100 in Rav. Fung. Carol. 1860 bears the name, *Ustilago foetens* B. & C.

Tilletea rotundata (Arth.) Massee.
Host.—*Panicum virgatum* L.

Specimens from Iowa.—Herb. Iowa State College, New Albin, L. H. Pammel. Herb. J. C. Arthur (type). Herb. Hume—(84) New Albin, L. H. Pammel.

Affected ovaries scarcely differ from unaffected, there is no swelling or other external mark which would indicate that they are affected.

Tilletia striæformis (West.) Fisch. de Waldh.
Host.—*Poa pratensis* L.; *Phlem pratense* L.; *Agrostis alba.*

Specimens from Iowa.—Herb. Iowa State College (120) (101) (102), Ames, L. H. Pammel; (121) (122), Ames, F. C. Stewart. Herb. Hume (50) Ames, G. W. Carver. Crypt. Dist. Iowa State College (3) (4) (5) Ames, G. W. Carver.

Tilletia subfusca N. Sp.
Host.—*Sporobolus neglectus* Nash.

Specimen from Iowa.—Type in the Ex. Herb. J. C. Arthur, collected at Spirit Lake by Dr. J. C. Arthur.

This species is altogether different from the two species described by Ellis (1) on Sporobolus, namely *T. asperifolia* and T. *montana.* Specimen No. 1895 Ell. & Ev. N. A. F. collected at Boise City, Mont. by Gustave Smith, was made by Massee, the type of a new species, *Tilletia mixta.* My species somewhat resembles Massee's, but differs from it in having smaller and lighter colored spores. Most of those examined and measured in Dr. Arthur's specimens were 14u and none were above 16u. The spores nearly always appear to be smooth and on a few only were small scattered spines found.

On these differences it has been provisionally described as a new species.'

Neovossia Körn, Oestr. Bot. Zeitschr. 29:217. 1879.

(1) Journal of Mycology 8:55. An. 1887.

USTILAGINÆ OF IOWA.

BY H. H. HUME.

Ustilago, Persoon Syn. Fung. 224. 1801.

Mycelium located in the tissues of the host, annual or perennial, spores produced from the mycelium at definite points on lines, stems or flowers, gelatinous at first, later pulverulent, in one species a hard, dark mass, smooth, echinulate or reticulated.

Spore masses in the inflorescence hard, irregular, variable in size, spores minutely spiny. U. Austro-americana.

Spore masses in the ovaries of *Avena sativa*, glumes destroyed, spores minutely spiny. U. avenæ.

Spore masses blackish, in the ovaries of *Bromos breviaristatus*, spores tuberculate with blunt projections. U. bromivora.

Spore masses in the ovaries of *Setaria Italica*, glumes not affected; spores subglobose or irregular, contents granulated. U. Crameri.

Spore masses in the inflorescence of *Hordeum vulgare*, glumes not totally destroyed, spores smooth. U. Hordei.

Spore masses in unexpanded inflorescence of *Stipa spartea*, spores small, 3-5u, smooth. U. hypodytes.

Spore masses in the ovaries of *Avena sativa*, glumes not destroyed, spores smooth. U. levis.

Spore masses between the nerves on the leaves, amphigenous spores smooth. U. longissima.

Spore masses in the inflorescence of *Hordeum vulgare*, glumes early destroyed, spores echinulate. U. nuda.

Spore masses light brown, spores golden brown, echinulate, when mature escaping through the upturned walls of the capsule. U. oxalidis.

Spore masses in the ovaries of *Setaria glauca;* spores brown tinged with yellow; spores minutely and sparsely echinulate. U. panici-glauci.

Mycelium perennial; spore masses in the ovaries, brownish black spores smooth. U. perennans.

Spore masses in the ovaries, distended, swollen, spores minutely spiny. U. pustulata.

Spore masses in the unopened inflorescence of *Panicum sanguinale* and *P. glaucum;* spores 8-15 u; minutely echinulate. U. Rabenhorstiana.

Spore masses in the ovaries of *Eragrostis major*, spores densely echinulate. U. spermophora.

Spore masses in the unopened inflorescence of *Panicum capillare, P. proliferum* and *C. tribuloides;* blackish, spores minutely echinulate. U. syntherismæ.

Spore masses in the ovaries, of *Triticum vulgare;* spores echinulate. U. tritici.

Spore masses in the ovaries brownish violet, spores violet, widely and deeply reticulated. U. utriculosa.

Spore masses on leaves, flowers, stems, or roots; spores very variable in shape, echinulate. U. zeæ.

Spore masses completely destroying the panicle; spores 12-18u, densely and coarsely tuberculate. U. Arthurii.

Ustilago Austro-americana, Speg.

Ustilago Austro-americana Speg. Fungi argentini **4**: 19.

Exsiccati.--Ell. and Ev. N. A. F., 2262.
Sey. and Ear. Ec. F. 372.

Spore masses in the inflorescence, brownish black, hard, irregular in size and shape; spores globose or slightly elliptical; light brown; 10-15x8-9u; epispore distinct, bearing minute spines.

Host.—*Polygonum incarnatum* Ell.

Specimens from Iowa.--Ex. Herb. J. C. Arthur (1737), Ames; C. E. Bessey; Herb. Hume (14) Ames, H. Harold Hume.

The spores are bound together in hard, compact, irregular,

dark colored masses, usually surrounded by a reddish brown membranous covering.

Ustilago Avenæ (Pers.) Jens.

Uredo segetum. g. Uredo, Pers. Syn. Meth. Fung. 224. 1801.

Uredo carbo, g. avenæ, Wallroth. Fl. Crypt. Germ. 217. 1833.

Ustilago carbo. a vulgaris C. avenacea. Tul. Mem. Sur. Ust.

Ust. comp. aux. Ured. 80. 1847.

Ustilago segetum var. avenæ, Jens. Om. Korn. Brand. 61. 1888.

Ustilago avenæ Jens. L. Char. des Cer. 4. 1889.

Exsiccati Ell. & Ev. F. Col. 539.

Sey. & Ear. Ec. F. 81.

Spore masses filling and destroying the ovaries, brownish black; spores, subglobose, oval or elliptical smoky brown; 5-6 x 6-10 u; epispore minutely echinulate.

Host.—Avena sativa.

Specimen's from Iowa.—Herb. Iowa State College.

(1), (5,) (6), (7), Ames, L. H. Pammel.

(2), (3), (4), F. C. Stewart; Crypt. Dist. Iowa State College A. M. A.

(11) Ames, G. W. Carver; Ex. Herb. J. C. Arthur (1696) Emmet Co.

R. I. Cratty, Ex. Herb. Hume (1) Ames, A. F. Sample.

Ustilago avenæ was for many years included with *tritici* and *hordei* under the name *segetum* until it was determined by Jensen that it would not develop either on barley or wheat. Upon the strength of this knowledge he separated it as *U. avenæ*. Kellerman and Swingle straightened out the synonymy and found the name should be *Ustilago avenæ* (Pers.) Jens.

This species is quite prevalent throughout the state but has doubtldss been confounded with *U. levis*. Great damage is wrought annually to the oat crop and the seed grain should be much more generally treated than it now is. At threshing time in Iowa, the smut spores are often present in such quantities as to give rise to a stifling dust.

Ustilago Bistortarum (DC) Koern.

This species was listed by J. C. Arthur in his memorandum of Iowa Ustilagineæ, Bull. Iowa Agrl. Col., Dept. Bot. 172. 1884. No specimens could, however, be found and it entered here on the authority of Dr. Arthur.

Host.—*Polygonum incarnatum.*

Locality.—Ames.

Ustilago bromivora (Tul.) Fisch. de Waldh.

Host.—*Bromus marginatus.*

Specimens from Iowa.—Herb. Iowa State College (11) (12) Ames, F. A. Sirrine.

The spores from the Iowa specimens are darker in color than those of N. A. F. 3052, and average smaller in size and are more regular in shape than those of Ec. F. 534. The markings of the epispore are the same in all cases.

Ustilago caricis (Pers.) Fuck. Symb. Myc. 39.

Listed by Arthur, Memorandum Iowa Ustilagineæ, Bul. Iowa Agrl. Col., Bot. Dept. **1884:** 172.

Ustilago Crameri Koern.

Host.—*Setaria Italica.*

Specimens from Iowa.—Herb. C. R. Ball, Ames; L. H. Pammel and C. R. Ball.

The glumes are apparenly little affected.

Ustilago hordei (Pers.) K. & S.

Host.—*Hordeum vulgare.*

Specimens from Iowa.—Herb. Iowa State College (23) Ames, G. W. Carver; Ex. Herb. J. C. Arthur (1676b) Ames, J. C. Arthur. Crypt. Dist., Iowa State College (7) Ames, G. W. Carver.

No specimens are at present found in the herbarium of the Iowa State College. The only material of the species from the state thus far was collected on the experimental plots on the college farm, June 11, 1900, by Mr. E. L. R. Walker and myself. In three plots it was quite common.

Ustilago hypodytes (Schlecht) Fr.

Host.—*Stipa spartea*, Trin.

Ustilago longissima (Sow) Tul.

Host.—*Glyceria* sp.

Specimens from Iowa.—Ex. Herb. J. C. Arthur (1637); Decorah, E. W. D. Holway.

Ustilago nuda (Jens) K. & S.

Host.—*Hordeum vulgare.*

Specimens from Iowa.—Herb. Iowa State College (22) Ames, G. W. Carver; Ex. Herb. J. C. Arthur (1676) Decorah, E. W. D. Holway.

Crypt. Dist. Iowa State College (1) Ames, G. W. Carver.

Ustilago oxalidis Ell. and Tracy. Jour. Myc. 6:77. 1890.

Exsiccati.—Ell. & Ev. N. A. F. 2424.

Spore masses in the ovaries, light brown; spores globose or subglobose, yellowish or golden brown; 10-16u: epispore thickly and sharply echinulate.

Host.—*Oxalis stricta.*

Specimens from Iowa.—Herb. Iowa State College (128) Ames, G. W. Carver.

This species has been searched for diligently by many collectors from the I. S. C. Botanical Department, but not until July 3, 1900, was it collected by Mr. G. W. Carver.

Ustilago Panici-glauci (Wallr.). Niessl.

Host.—*Setaria glauca.*

Specimens from Iowa.—Herb. Iowa State College (36) (37) (38) (39) Ames, L. H. Pammel; (40) Ames, C. B. Weaver; (35) Sioux City, L. H. Pammel; (47) Ames, L. H. Pammel; Ex. Herb. J. C. Arthur, (1722) Decorah, E. W. D. Holway; Charles City, J. C. Arthur; Herb. C. R. Ball, Ames, C. R. Ball; Herb. Hume (63) Boone, L. H. Pammel. Crypt. Dist. Iowa State College (2) Ames, G. W. Carver.

This Ustilago is very common in the state, usually appearing on the host in August and September, though the author has collected it as early as July 9th.

Ustilago perennans Rostr.

Host.—*Arrhenatherum avenaceum.*

Specimens from Iowa. Sey. & Ear. Ec. F. (83). Ames, F. A. Sirrine, and L. H. Pammel; Herb. Iowa State College (65) Ames, L. H. Pammel; (68) Ames, E. R. Hodson; (69) Ames, J. C. Arthur; (70) Ames, L. H. Pammel; (71, 72)

Ames, G. W. Carver. Crypt. Dist. Iowa State College (19), Ames, G. W. Carver.

Ustilago pustulata Tracy and Earle.

Host.—*Panicum proliferum.*

Specimens from Iowa.—Herb. Iowa State College (53) Ames, L. H. Pammel and Jared G. Smith. Herb. C. R. Ball, Ames, L. H. Pammel. The Ames specimens show only the ovaries of the host affected. They are distended and roundish, the enveloping membrane being grayish in color.

Ustilago Rabenhorstiana Kuhn.

Host.—*Panicum glabrum* and *Panicum sanguinale.*

Ustilago spermophora B. & C.

Host.—*Eragrostis major.*

Specimens from Iowa.—Herb. Iowa State College (73) Ames, L. H. Pammel; Ex. Herb. J. C. Arthur (1693); Decorah, E. W. D. Holway; Charles City, J. C. Arthur.

This species is doubtless common in the state, but it is generally overlooked as it produces no conspicuous distortion or discoloration of the affected parts of the host.

Ustilago syntherismœ (Schw.) Fisch. de Waldh.

Hosts.—*Panicum capillare, P. proliferum,* and *Cenchrus tribuloides*

Specimens from Iowa.—Herb. Iowa State College (13) Wilton Junction, L. H. Pammel; (17) (18) Ames, C. E. Bessey; (76) Ames, F. C. Stewart; (77) Ames, P. H. Rolfs; (78) Ames, L. H. Pammel; (79) Ames, P. H. Rolfs; (80) F. C. Stewart; (87) Ames, L. H. Pammel; (88) Ames, P. H. Rolfs; Herb. C. R. Ball, Ames, C. R. Ball, Crypt. Dist. Iowa State College (14), Ames, H. H. Hume. Herb. Hume (65) Des Moines, L. H. Pammel; (66) Boone, L. H. Pammel.

The forms of *Panicum capillare* and *panicum proliferum* are identical, while between these two and the one on *Cenchrus tribuloides* there is no appreciable morphological distinction. The different hosts are often found associated, and when in proximity the one is affected if the

other is. Still there may be biological differences, or the two may be distinct, though the writer does not think so.

Ustilago Tritici, (Persoon) Jensen.

Host.—*Triticum vulgare.*

Specimens from Iowa.—Herb. Iowa State College (91 Ames, F. C. Stewart; (92) Ames, C. B. Weaver; (144) Council Bluffs, L. H. Pammel. Crypt. Dist. Iowa State College (6), Ames, G. W. Carver. Herb. C. R. Ball, Ames, F. C. Stewart.

Ustilago utriculosa (Nees) Fries (Nees) Tul.

Host.—*Polygonum lapathifolium*, var. incarnatum. Wats., P. *Pennsylvanicum*, L., P. *hydropiper.*

Specimens from Iowa.—Herb. Iowa State College (93) Greenfield, F. C. Stewart. (95 and 96) Ames, C. E. Bessey.

Ex. Herb. J. C. Arthur 3 (1737) Charles City, J. C. Arthur; Decorah, E. W. D. Holway.

Herb. C. R. Ball, Ames, C. R. Ball.

Herb. Hume, (18 & 8) Ames, H. Harold Hume.

Crypt. Dist. Iowa State College (30) Ames, A. F. Sample.

Every flower in the head is usually destroyed and much swollen. One specimen in Professor Arthur's herbarium, on P. hydropiper, collected at Charles City, showed spores lighter in color and with somewhat smaller reticulations than usual.

It is altogether probable that the species now know as *Sphacelotheca Hydropiperis* (Schum.) DeBary was at one time confused with this species. The figure given by Nees, both in Das. Syst. der Pilze and Schw. does not resemble the cut given by Corda, nor does it look like *utriculosa* as we know it. Corda's illustration is good for this species but not of those given by Nees, (1817 and 1834) are quite like *Sphacelotheca hydropoperis* (Schum.) DeBary.

Ustilago Zeæ (Beckm.) Ung.

Host.—*Zea Mays. Euchlena luxurians.*

Specimens from Iowa.—Herb. Iowa State College (25) Ames, F. C. Stewart; (28) (29) (30) (31) (32) L. H. Pammel; (33) G. P. Miller; (34) C. E. Bessey, Emmet Co.; Ex. Herb. Hume (13) Ames, H. Harold Hume; (67) Boone, L. H.

Pammel; Herb. C. R. Ball, Ames, F. C. Stewart; Crypt. Dist. Iowa State College (16) Ames, A. F. Sample; (15) Ames, A. F. Sample.

The spores are at first enclosed in a whitish gelatinous membrane. This is eventually ruptured and the spores escape. It is found in Iowa wherever corn is grown and annually occasions losses amounting to thousands of dollars.

At first I thought that the fungus on *Euchlena* might be different but on careful examination concluded that so far as morphological differences were concerned, that it was *Ustilago zeæ*. The synonymy as given above has been adopted directly from Magnus, though most of it has been personally verified.

Ustilago Arthurii N. Sp.

Host.—*Panicularia americana*, (Torr.) MacM.

Specimens from Iowa.—Types in Ex. Herb. J. C. Arthur were collected at Spirit Lake, Iowa, July 5, 1899, by Dr. J. C. Arthur.

Dr. Arthur's note made presumably at the time of collection was, "Affected plants have the heads totally destroyed."

Cintractia Cornu. Ann. Sci. Nat. Bot. 6:15. 277–279., 1883.

Cintractia sorghi (Sorok.) De Toni.

Host.—*Andropogon Sorghum.*

Specimens from Iowa.—Herb. Iowa State College (74) Ames, H. Harold Hume and Otto Evers.

All the ovaries of the affected plants were filled with spores and a sharp, central columella was present. The flowers were too old to make out the spore masses in the stamens.

Cintractia Junci (Schw.) Trel.

Host.—*Juncus tenuis.*

Specimens from Iowa.—Herb. Iowa State College (131) & (132) Ames, C. E. Bessey; (133) Ames, Hitchcock.

Cintractia sphærogena (Burrill.)

Host.—*Panicum crus-galli.*

Specimens from Iowa.—Herb. Iowa State Colle ge (120 Clinton, L. H. Pammel.

The spore masses are quite hard and so compact as to be easily sectioned. A cross section reveals the presence of a portion of the plant tissues among which may be seen, upon microscopical examination, the remains of the mycelium. From this the spores are arranged basipetally. Consequently it appears that this species belongs more properly to the genus *Cintractia*. In 1896 Dr. P. Mangus described *Cintractia Seymouriana* occuring on *Panicum crus-galli* but his fungus affected only the culms and leaves, and for this reason it appears to be different. So far as known the species under consideration affects only the ovaries. Hence this fungus occuring in the ovaries of *P. crus-galli* has been provisionally transferred to the genus Cintractia, as *Cintractia sphærogena* (Burrill.)

Cintractia Reiliana (Kuehn.) Clinton.

Host.—*Sorghum* sp. probably *vulgare*.

Specimens from Iowa.—Herb. Iowa State College (55,) Monticello, E. E. Reed.

The fibro-vascular bundles of the affected portion remain intact, serving as a sort of network in which the spores are held. The specimen from which the above description was drawn was collected in 1894 and is so far as known the only one ever taken in the state. It is probably more common than the number of specimens would indicate.

Tilletia Tul. Ann. Sci. Nat. Bot. 7:112. 1847.

Tilletia foetens Trelease.

Host.—*Triticum vulgare* L.

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Though no description of this species was published by Berkeley and Curtiss until 1874, still specimen No. 100 in Rav. Fung. Carol. 1860 bears the name, *Ustilago foetens* B. & C.

Tilletea rotundata (Arth.) Massee.
Host.—*Panicum virgatum* L.

Specimens from Iowa.—Herb. Iowa State College, New Albin, L. H. Pammel. Herb. J. C. Arthur (type). Herb. Hume—(84) New Albin, L. H. Pammel.

Affected ovaries scarcely differ from unaffected, there is no swelling or other external mark which would indicate that they are affected.

Tilletia striæformis (West.) Fisch. de Waldh.
Host.—*Poa pratensis* L.; *Phlem pratense* L.; *Agrostis alba.*

Specimens from Iowa.—Herb. Iowa State College (120) (101) (102), Ames, L. H. Pammel; (121) (122), Ames, F. C. Stewart. Herb. Hume (50) Ames, G. W. Carver. Crypt. Dist. Iowa State College (3) (4) (5) Ames, G. W. Carver.

Tilletia subfusca N. Sp.
Host.—*Sporobolus neglectus* Nash.

Specimen from Iowa.—Type in the Ex. Herb. J. C. Arthur, collected at Spirit Lake by Dr. J. C. Arthur.

This species is altogether different from the two species described by Ellis (1) on Sporobolus, namely *T. asperifolia* and T. *montana*. Specimen No. 1895 Ell. & Ev. N. A. F. collected at Boise City, Mont. by Gustave Smith, was made by Massee, the type of a new species, *Tilletia mixta*. My species somewhat resembles Massee's, but differs from it in having smaller and lighter colored spores. Most of those examined and measured in Dr. Arthur's specimens were 14u and none were above 16u. The spores nearly always appear to be smooth and on a few only were small scattered spines found.

On these differences it has been provisionally described as a new species.'

Neovossia Körn, Oestr. Bot. Zeitschr. 29:217. 1879.

(1) Journal of Mycology 3:55. An. 1887.

Neovossia Iowensis Hume and Hodson.

Spore masses filling the ovaries, black; spores globose, subglobose or ovate, brownish black, opaque; 16x20–24x 28u; enclosed in a hyline capsule; appendage hyaline, slender, two or three times the length of the spore; epispore apparently pitted.

A careful comparison with the specimen in De Thuemen's Mycotheca Universalis leads to the belief that the Iowa specimens are specifically distinct. The spores differ from those of *Neovossia moliniæ* (Thum.) Körn being darker in color, broader, and blunter, and proportionally shorter at the end opposite the appendage. The markings of the epispore are somewhat coarser.

Several attempts were made to germinate the spores in order to throw some light upon the vexed question of the true status of the genus *Neovossia*, but thus far unfortunately all trials have resulted in failure. However, based entirely upon the morphological distinctions it is the author's belief that the genus has sufficient reasons for its existence.

Host.—*Phragmitis communis* Trin.

Specimens from Iowa.—Material collected at Colo, Iowa, by E. R. Hodson, Sept. 23, 1899.

Entyloma DeBary, Bot. Zeit. 1874: 101.

Entyloma compositarum Farl.

Host.—*Lepachys pinnata* Torr. & Gray., and ***Ambrosia*** *artemisiæfolia*, L.

Specimens from Iowa.—Herb. Iowa State College (143) Ames, A. S. Hitchcock; (136) Jewell Jc., G. W. Carver.

Ex. Herb. J. C. Arthur (1813) Decorah, E. W. D. Holway; Ex. Herb. Hume Ames, Iowa, H. Harold Hume; Ames, G. W. Carver.

Entyloma crastphilum, Sacc.

Host.—*Phleum pratense*, L.

Specimens from Iowa.—Herb. Iowa State College (136 Decorah, E. W. D. Holway.

I have carefully compared No. 1301, Krüger's Fungi Saxonici, on *Holcus lanatus* and the two are apparently identical.

Entyloma Linariæ, Schroet.

Host.—*Veronica peregrina*, L.

Specimens from Iowa.—Herb. Iowa State College (144) Ames, A. S. Hitchcock.

Entyloma Menispermi, Farl & Trel.

Host.—*Menispermum Canadense*, L.

Specimens from Iowa.—Herb. Iowa State College 134) Ames, L. H. Pammel; (131) Ames, P. H. Rolfs and L. H. Pammel, (132) Ames, G. W. Carver; (133) Ames, Zmunt. Ex. Herb. J. C. Arthur (1814) Decorah, E. W. D. Holway.

Entyloma microsporum, (Ung.) DeBary.

Host.—*Ranunculus septentrionalis*, Poir.

Specimens from Iowa.—Ex. Herb. J. C. Arthur (1810) Decorah, E. W. D. Holway.

Entyloma physalidis (Kalch & Cke) Farl.

Host.—*Physalis Virginiana, P. lanceolata, P. Philadelphica, P. heterophylla.*

Specimens from Iowa.—Herb. Iowa State College (138) Ames, P. H. Rolfs; (141) Boone, L. H. Pammel; (142) Ames, G. W. Carver; (143) Council Bluffs, L. H. Pammel.

Ex. Herb. J. C. Arthur, (1815) Charles City, J. C. Arthur; Decorah, E. W. D. Holway; Ames, C. E. Bessey. Ex. Herb. Hume.

On some species of Physalis the affected spots are quite elevated on one side while on the opposite side there is a corresponding depression.

Entyloma polysporum (Pk.) Farl.

Host.—*Ambrosia trifida*, L.

Specimens from Iowa.—Herb. Mo. Bot. Garden. Herb. Hume, (88) Ames, G. W. Carver.

It is my belief that this species is distinct from *Entyloma compositarum*, Farl. The appearance of the spots is characteristically different, darker and more angular, a difference which is apparently independent of the degree of maturity of the disease. *Entyloma compositarum*, Farl. on

Ambrosia artemisiæfolia, L. is very common in the region of Ames and though *Ambrosia trifida* and *Ambrosia artemisiæfolia* are equally common, I have never collected the *Entyloma* on the former host though I have frequently collected *Ent. compositarum* on plants of *Ambrosia artemisiæfolia* growing side by side with *Ambrosia trifida.*

Entyloma saniculæ, Pk.

Host.—*Sanicula Canadensis*, Torr.

Specimens from Iowa.—Ex. Herb. J. C. Arthur (1823) Decorah, E. W. D. Holway.

Entyloma leuto-maculans, N. Sp.

Host.—*Mertensia Virginica*, DC.

Specimens from Iowa.—Type specimen in Ex. Herb. J. C. Arthur, collected at Decorah, Iowa, by E. W. D. Holway, May 31, 1885.

I have compared this with the two European species occurring on Boraginaceæ and it appears to be different. The character of the spots is quite unlike either, being lighter in color and surrounded (in a dried specimen) by a slightly elevated ring. The spores are thick walled and average larger in size, than either *Entyloma canescens*, Schroet., or *Entyloma serotinum*, Schroet. (Specimen 213 Kunze Fungi selecte, on *Myosotodis intermedia*, and 354 Krüger's Fungi Saxonici on *Symphytum tuberosum* examined.)

Entyloma Pammelii, N. Sp.

Host.—*Zizania aquatica.*

Specimens from Iowa.—Type specimen in Ex. Herb. J. C. Arthur (1806) collected at Decorah, Iowa, Oct. 11, 1885, by E. W. D. Holway.

This differs from *Entyloma crastophilum*, Sacc. and from *Entyloma irregulare*, Johans, in the color and size of the spots and the lighter color and more angular shape of the spores. *Entyloma crastophilum*, Sacc. on *Holcus mollis*, L. No. 1301. Krüger's Fungi Saxonici and *Entyloma irregulare*, Johans on *Poa annua*, No. 1402. Krüger's Fungi Saxonici 1301 was used for comparison. To this species is also referred the specimens collected by Dr. Pammel at

Madison, listed as *Entyloma crastophilum*, Sacc. by Dr. Trelease. Specimens in Herbaria of Iowa State College and Mo. Bot. Garden examined.

Host.—*Polygonum sagittatum*, L.

Locality.—Charles City.

Schizonella, Schröet. Pilze. Schles. 275. 1887.

Schizonella melanogramma (DC.) Schroet.

Host.—*Carex Pennsylvanica*, Lam. Carex sp.

Specimens from Iowa.—Herb. Iowa State College (114) Steamboat Rock, L. H. Pammel; (115) Boone, Miss Zimbleman; (116), (117) Ames, L. H. Pammel. Crypt. Dist. Iowa State College (17), Ames, G. W. Carver.

Tolyposporium, Woron. Schröet. Pilze. Schles. 276. 1882.

Tolyposporium bullatum Schroet.

Host.—*Panicum crus-galli*, L.

Specimens from Iowa.—Herb. Iowa State College (130) Ames, C. E. Bessey.

This specimen was collected by Dr. C. E. Bessey on September 29, 1874 and is certainly well worthy of note. The ovaries are swollen and congested and protrude from the glumes, otherwise the flower is uninjured; the glumes remain intact and apparently develop normally. In microscopic appearance it resembles *Ustilago pustulata* Under a magnification of about 20 diameters the spore balls appear as rounded granules.

Doassansia Cornu. Ann. Sci. Nat. Bot. VI: 15: 285. 1883.

Affecting acquatic plants. Spore masses consisting of a large number of fertile spores surrounded and enclosed by a covering of sterile spores, imbedded in the plant tissues.

Doassania, Sp.

Specimen on Sagittaria variabilis, Ex. Herb. J. C. Arthur (1843) Decorah, E. W. D. Holway.

This specimen was very small and since Dr. J. J. Davis had said it was too imature for identification, no attempt was made to name it. The sori, however, appeared to be quite different from those of *Doassansia sagittariae* West) Fisch.